

# **THE USE OF RECOVERY MODALITIES BY ENDURANCE RUNNERS**

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\_\_\_\_\_ Hanette Lemke \_\_\_\_\_

(Signature)

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## LIST OF ABBREVIATIONS

1 RM	One repetition maximum
ACSM	American College of Sports Medicine
ASA	Athletics South Africa
ATP	Adenosine triphosphate
BMI	Body mass index
°C	Degrees Celsius
CHO	Carbohydrates
CK	Creatine kinase
CNS	Central nervous system
CRP	C-reactive protein
CTW	Contrast temperature water immersion
CWI	Cold water immersion
DM	Diabetes mellitus
DOMS	Delayed onset of muscle soreness
Exp(B)	Exponentiation of the B-coefficient
g.kg <sup>-1</sup>	Grams per kilogram
g.kg <sup>-1</sup> .d <sup>-1</sup>	Grams per kilogram of bodyweight per day
HR	Heart rate
HREC	Human Research Ethics Committee
IL-1ra	Interleukin-1ra
IL-1β	Interleukin-1β
IL-2I	Interleukin-2I

IL-6	Interleukin-6
ISSN	International Society of Sports Nutrition
MVC	Maximal voluntary contraction
NSAIDS	Non-steroidal anti-inflammatory drugs
PGC-1 $\alpha$	Peroxisome proliferator-activated receptor gamma co-activator-1 alpha
PRS	Peak running speed
RCT	Randomised controlled trial
ROM	Range of motion
RRI	Running-related injuries
UCT	University of Cape Town
VAS	Visual analogue scale
WBC	Whole body cryotherapy

## **GLOSSARY OF TERMS**

Cryotherapy	The cooling of a body part.
Eccentric exercise	A voluntary muscle activity during which the muscle lengthens while under tension.
Effleurage	A massage technique consisting of stroking motions with the palm of the hand.
Epidemiology	The science of factors determining and influencing the frequency and distribution of disease, injury, and other health-related events and their causes in a defined human population.
Ergogenic	A tendency to increase work output.
Homeostasis	The tendency of the normal physiological state of an organism to acquire stability.
Hypoglycaemia	A very low concentration of glucose in the blood.
Hyponatremia	A low concentration of sodium in the blood plasma.
Isokinetic	The maintenance of a constant tension during muscles contraction.
Nociceptors	A sensory receptor that responds to pain.
Petrissage	A massage technique involving kneading and rubbing the muscles.
Recovery	A return to a normal condition.

## **ABSTRACT**

### **Background**

Overtraining and exercise-induced muscle injuries are common in endurance runners. A well-planned recovery protocol is crucial to limit fatigue and prevent injuries. There are multiple modalities available to aid the recovery process and facilitate optimal performance. However, there is limited information regarding the prevalence and pattern of use of recovery modalities in endurance runners, as well as the factors that may influence runners' decisions to use different recovery modalities. This information is important for the promotion of safe and effective use of recovery modalities and to identify potential educational requirements for athletes using recovery modalities.

### **Aim and objectives**

The aim of this study was to describe the use of different recovery modalities and regimes by endurance runners following training and races. The specific objectives of the study were: (a) to obtain information on recovery modalities used by endurance runners, such as the type of modalities, frequency of use, and use during training and races; (b) to determine the factors that influence endurance runners when selecting recovery modalities; (c) to determine the knowledge endurance runners have of the perceived effectiveness of recovery modalities; (d) to explore associations between the use of recovery modalities in endurance runners and socio-demographic factors, such as, gender, age, body mass index, monthly income, level of education and training and competition history.

### **Methods**

This study had a descriptive correlation design. Adult runners who had been running for at least six months in the 12-month period preceding the study, and who were training a minimum of 30 km.wk<sup>-1</sup> were included in this study. Participants who failed to provide informed consent or did not complete the mandatory sections of the questionnaire were excluded from the study. Participants were recruited at races and by contacting South African running clubs. Participants were required to complete a self-developed questionnaire that included demographic information, training and racing history, and the self-reported use of recovery modalities. The questionnaire was validated by a panel of experts. It was available in both hard copy and electronic format.



## Results

The study sample consisted of 433 participants (males 64%; females 36%), who were mostly well-educated with a tertiary degree or diploma. More than 80% of participants were predominantly road runners. Participants in this study reported using the twelve recovery modalities regularly, with passive recovery (90%), active recovery (76%) and stretches (67%) being the most commonly used modalities. Participants used a mean of  $6 \pm 2$  different recovery modalities. All recovery modalities were commonly used during training and races, while cryotherapy, anti-inflammatory medication, contrast therapy, heat and massage were more commonly used after injury or for the management of pain. A protein supplement was used by 60% of participants, compared to 37% of participants' who reported using carbohydrate supplements.

Between 10% and 19% of participants did not know the proposed mechanism of action of different recovery modalities. Personal experience and information from fellow runners were the two main resources that influenced participants' use of different recovery modalities. Approximately 90% of participants reported that passive recovery and massage were effective recovery modalities, while over 30% of participants thought carbohydrates, compression, vitamins and minerals were less effective in assisting recovery from training and competition. Demographic factors such as gender, age, level of education and monthly income predicted the use of carbohydrates, protein, massage, anti-inflammatory medication, active recovery and compression. Training factors associated with more experience (for example number of marathons) predicted the use of vitamins and minerals, anti-inflammatory medication, active recovery and compression. The presence of a current injury predicted the use of cryotherapy, heat and contrast therapy.

## Conclusion

In conclusion, this study showed there is widespread use of recovery modalities among endurance runners, despite the lack of evidence for their efficacy. Unsafe and inappropriate practices were identified, which may compromise performance, but may also place endurance runners at risk of serious adverse events during both training and competition. A major challenge is the strong influence of personal experience and information from fellow runners on the choice of recovery modalities. Educational initiatives, with a focus on peer-led education, are essential to encourage the safe and effective use of recovery modalities.

# 1 CHAPTER ONE: INTRODUCTION AND SCOPE OF THE DISSERTATION

## 1.1 INTRODUCTION

The world's running population is large and still increasing. In 2009 there was an estimate of 30 million runners worldwide<sup>1</sup>. The running population includes a wide variety of athletes, from recreational runners who run occasionally to elite ultra-marathon athletes<sup>2</sup>. Endurance running may be associated with numerous health benefits, including a reduction in the development of risk factors for diseases of lifestyle, for example, diabetes, cancer, cardiovascular diseases and coronary artery disease.

However, endurance training programmes need careful planning to maximise the positive physiological adaptations and benefits of running, while avoiding or minimising the negative effects of exercise-induced muscle damage, fatigue and running related injuries<sup>2,3</sup>.

A good training programme must consider multiple components, namely: the status of the relevant anatomical structure of the athlete; the type of the applied stresses or load during exercise; the frequency, intensity and duration of the applied load; and the recovery times and adaptation periods between training sessions<sup>4</sup>. Acute recovery between training sessions becomes vital to support training loads<sup>5</sup>, as prolonged or repeated training sessions cause the breakdown of muscle protein, resulting in structural, metabolic and physiological changes<sup>5,6</sup>.

Adequate recovery after training and competition is essential to facilitate the positive effects of endurance running training, and to minimise negative training effects such as exercise-induced muscle damage and fatigue<sup>7,8</sup>. An effective recovery strategy may prevent training-related musculoskeletal injuries, and may also optimise performance<sup>2,3,9,10</sup>. Recovery is a passive process; however there are numerous commercially available recovery modalities and recovery strategies that are used by athletes to increase the rate and quality of their recovery after races or training<sup>9</sup>.

Recovery modalities include nutritional substances such as proteins, carbohydrates (CHO), vitamins and caffeine; or activities and techniques such as light exercise or active recovery, stretches, cryotherapy, heat therapy, massages, water immersion, compression garments or simply rest<sup>11–26</sup>. Although there are evidence-based guidelines for the use of some recovery modalities<sup>3,9,16,20</sup>, there is equivocal and often conflicting evidence on the majority of recovery modalities and strategies<sup>27,28</sup>. Some studies have shown that recovery modalities may not enhance the recovery process, and that certain modalities or strategies may have little or no effect on exercise performance<sup>3,19,20,27–29</sup>.

There is limited literature regarding the use and effectiveness of recovery modalities in endurance runners. However, anecdotal reports suggest that the use of recovery modalities is common practice, despite the lack of evidence of the efficacy of many modalities. An understanding of the scope of use of recovery modalities is therefore necessary to guide further research in this area, and to promote safe recovery strategies by endurance runners.

## **1.2 AIMS AND OBJECTIVES**

### **1.2.1 Aim**

The aim of this study was to describe the use of different recovery modalities by endurance runners.

### **1.2.2 Specific objectives**

- To determine the pattern of use of recovery modalities by endurance runners, such as the types of modalities, frequency of use, and use during training and races.
- To determine the factors that influence endurance runners when selecting recovery modalities.
- To determine the knowledge endurance runners have on the perceived effectiveness of recovery modalities.
- To explore associations between the use of recovery modalities by endurance runners and socio-demographic factors, such as gender, age, body mass index (BMI), monthly income, level of education; and training and competition history.

### **1.2.3 Significance of this dissertation**

The purpose of this study is to gain insight and knowledge into the utilisation of recovery modalities by endurance runners, and to investigate potential reasons for the selection and use of different modalities. This study may also provide information on the need for education regarding the appropriate use of recovery modalities.

### **1.3 PLAN OF DEVELOPMENT**

In preparation for the investigational phase of this dissertation, a comprehensive review of the literature on recovery modalities used by endurance runners will be presented (Chapter 2). This will be followed by a descriptive questionnaire-based study, designed to describe the use of recovery modalities by endurance runners (Chapter 3).

Chapter 3 will also include the limitations of this study and recommendations for future research. A summary and conclusion section (Chapter 4) will complete this dissertation.

## 2 CHAPTER TWO: LITERATURE REVIEW

### 2.1 INTRODUCTION

Running is a popular activity as it can be practiced anywhere with minimal equipment. The running population includes a wide variety of athletes, from recreational runners to elite ultra-distance marathoners<sup>2</sup>. Endurance running is a complex sport. Regular participation is associated with numerous health benefits and positive adaptations to the cardiovascular, neuromuscular and metabolic system<sup>4</sup>. However, endurance running training and competition may also be associated with negative effects, such as exercise-induced muscle damage, fatigue and running-related injuries<sup>3,30,31</sup>. Recovery is essential to facilitate the positive effects of endurance running training and to minimise negative effects of regular training and competition<sup>7,8</sup>. There are multiple recovery modalities that may increase the rate and quality of their recovery after competition or training<sup>3,4,9,19,27,32</sup>. However, there is equivocal evidence for many recovery modalities that are commonly used by athletes. There is also conflicting evidence for the efficacy of many recovery modalities for endurance running.

Therefore, this literature review will provide a brief overview of the positive and negative effects of endurance running training and competition. The concept of recovery will be introduced. The focus of this literature review will be the description of commonly used recovery modalities. Finally, the proposed physiological mechanisms and strategies for the use of each modality will be reviewed; and current evidence to support the use of each modality will be discussed.

Several databases were utilised for this literature search. These databases included PubMed, ScienceDirect, PEDro, the Cochrane Library, Google Scholar and SpringerLink. The primary search terms included *“endurance sport”, “runners”, “athletes”, “recovery”, “overtraining”, “DOMS”, “fatigue”, “cryotherapy”, “anti-inflammatory medication”, “nutrition”, “protein”, “carbohydrates”, “vitamins”, “stretching”, “heat”, “compression garments”, and “massage”*. These words and their variations were used in several different combinations to maximize retrieval of relevant articles for the study.

## **2.2 ENDURANCE RUNNING AS A SPORT**

There is evidence that the first marathon was run by the soldier Pheidippides in 490 B.C. He ran from the Greek town of Marathon to Athens, announcing victory on the battleground. Since then the marathon has grown in popularity. Also, there is an increased awareness of the importance of daily exercise and physical fitness to ensure healthy living<sup>7</sup>. Physical fitness is defined by Genton<sup>33</sup> as “*a set of attributes that people have or achieve relating to their ability to perform physical activity*”. Physical fitness is comprised of physiological fitness, health-related fitness and skill-related fitness. Physiological fitness involves all systems that allow and enable the body to perform physical exercise<sup>33</sup>. Testing the limits of the body’s fitness and endurance capacity by prolonged exercise has fascinated humans for a long time<sup>8</sup>. Endurance exercise is the ability to perform prolonged, sustained physical exercise or activity<sup>27</sup>.

Endurance training and physical exercise such as distance running, have multiple physical and psychological benefits<sup>3,27</sup>. Unfortunately, running-related injuries are very common<sup>30,31,34</sup>. Endurance training has numerous potential negative effects<sup>35</sup>. The next section will provide a brief overview of the positive physiological adaptations and the negative effects of regular endurance running training and competition.

## **2.3 POSITIVE PHYSIOLOGICAL ADAPTATIONS ASSOCIATED WITH ENDURANCE RUNNING TRAINING**

Various organs, tissues and mechanisms adapt to endurance sport. There are multiple benefits associated with running. These include increased fitness and health, weight loss, a decrease in depression, and improved psychosocial levels. Cardiovascular, muscular and neurological adaptations are important to enable an endurance athlete to run economically and compete successfully<sup>36</sup>.

### **2.3.1 Cardiovascular adaptations**

Endurance running can improve the capacity of the cardiovascular system<sup>3</sup>. During exercise, heart rate and cardiac output increase to enable more blood to flow and transport oxygen to the active muscles and the brain. Cardiac output is a function of the stroke volume and heart rate, or the volume of blood that the heart pumps per contraction. During regular endurance training the cardiovascular system adapts to be more efficient<sup>36,37</sup>. Regular endurance training increases the blood volume of the body, which enhances the perfusion of the active muscles, but also enlarges the preload on the ventricles. This leads to an increase in the stroke volume of the heart<sup>3,27</sup>.

The heart is then able to increase the cardiac output as more blood is ejected with each cardiac contraction. As the load on the heart is decreased, the heart rate and blood pressure decreases in rest and during exercise<sup>3,27</sup>.

### **2.3.2 Metabolic adaptation of the musculoskeletal system**

Any activity such as endurance running, which relatively low intensity and continues for longer than three minutes, depends mostly on the aerobic metabolism of the body<sup>3,12</sup>. Aerobic metabolism produces energy through oxidative phosphorylation. During training, this aerobic process takes place in the active muscle's mitochondria. In the mitochondria, glucose and oxygen enter the Krebs cycle to generate energy or adenosine triphosphate (ATP). Carbohydrates, amino acids, fat or lactate can be converted into glucose to produce ATP in the Krebs cycle. Oxygen needs to be transported by the red blood cells to the muscles to ensure adequate energy production and oxidation capacity of the muscles<sup>3,27,36</sup>.

Regular running can significantly improve the metabolic function and oxidation capacity of muscles, allowing a runner to use energy more economically and therefore experience less fatigue. Endurance training increases the activation frequency of muscle fibres, leading to an expansion of the capillary network of active muscles, thereby improving the blood distribution of a muscle. This will increase the time span for blood flowing through the muscle tissue, thereby improving the gas and metabolic exchanges between the capillaries and the muscles. Exercise raises the temperature of the body and decreases the pH of the active muscles, enhancing the capacity of the haemoglobin to unload oxygen. Regular training further increases the mitochondrial proteins, increasing the number of Krebs cycles, and therefore enabling more ATP to be released during activity<sup>3,27</sup>. Glucose or glycogen is the preferred energy source during activity, releasing ATP during the Krebs cycle. Regular endurance training also increases the enzyme activity that metabolises carbohydrates and fat or free fatty acids, causing the glycogen stores to be spared, which further enable an athlete to run burning less energy<sup>27,36</sup>.

### **2.3.3 Mechanical adaptation of the musculoskeletal system**

Regular resistance training and eccentric loading can help to improve an athlete's performance and running economy<sup>38</sup>. Muscles that are exposed to repeated mechanical loading or sufficient resistance to overload the muscles can be positively remodelled and strengthened. Exercise sessions can have a cumulative training effect on the body, causing long-term adaptation of tissues to enhance performance<sup>24</sup>. High intensity, low repetitive exercise has been shown to be the most effective in causing muscle hypertrophy. Muscle hypertrophy results in an increase in speed and power that is important for elite endurance athletes<sup>3</sup>.

Regular endurance running alone does not have a major effect on the size of a muscle and is unlikely to lead to muscle hypertrophy<sup>3</sup>. If the muscles are exposed to excessive forces or if there is insufficient recovery time following training, the muscle structures can weaken and this may result in an overuse injury<sup>9,31,39</sup>.

## **2.4 NEGATIVE EFFECTS OF REGULAR ENDURANCE RUNNING TRAINING AND COMPETITION**

There are negative effects associated with long distance running. These include exercise-induced muscle damage, delayed onset muscle soreness, fatigue and overtraining<sup>3,37</sup>. In addition, long distance runners have a relatively high risk of injury<sup>37,40</sup>. This section will review these main negative effects of regular endurance running training and competition in more detail.

### **2.4.1 Exercise-induced muscle damage**

Exercise-induced muscle damage is a common occurrence after eccentric or unfamiliar exercise<sup>41,42</sup>. Eccentric exercise causes muscles to undergo a powerful stretch to lengthen during an active contraction resulting in muscle fibre damage<sup>43,44</sup>. This muscle fibre damage has a mechanical as well as a metabolic influence. Mechanically the muscle damage is a result of the eccentric loading or lengthening of the muscle fibrils beyond its normal state of contraction resulting in z-band streaming<sup>41,45</sup>. These structural changes of the muscle fibres may lead to the symptoms of exercise-induced muscle damage like delayed onset of muscle soreness (DOMS), oedema and a loss of muscle elasticity and strength<sup>43</sup>. Exercise-induced muscle damage causes changes in gait kinematics during walking<sup>46</sup>. Therefore unaccustomed or eccentric exercise resulting in exercise-induced muscle damaged may reduce the performance level of an athlete as healing might take up to three to four weeks or even a longer period of time<sup>41,47</sup>. The metabolic damage is due to metabolic processes that occur as a result of exercise induced muscle damaged. Decreased insulin sensitivity, prolonged glycogen reduction, and a change in the metabolic rate are some of a number of metabolic processes that are associated with exercise-induced muscle damage. Decreased (Ca<sup>2+</sup>)-adenosine triphosphatase activity, resulting in Ca<sup>2+</sup> build up in the sarcoplasm, is another metabolic process associated with exercise-induced muscle damage that can initiate further damaging metabolic processes<sup>45</sup>.

Armstrong (1990)<sup>48</sup> described four stages of an integrated model of muscle damage. These stages are (i) initial events; (ii) autogenic processes; (iii) the phagocytic stage; and (iv) the regenerative phase. This model describes an initial acute inflammatory response after muscle damage<sup>48</sup>.



The muscle fibres experience high mechanical tension resulting in metabolic changes and the loss of cellular homeostasis. Leukocytes infiltrate the muscle fibres and pro- and anti-inflammatory cytokines, such as delta interleukin-1 $\beta$ , interleukin-1 $\alpha$ , interleukin-6, and interleukin-21, are produced and the damaged muscle fibres are broken down and removed. Intercellular enzymes such as creatine kinase, are released and appear in the blood. Special cytokines in the body regulate the penetration of these inflammatory cells into the muscle tissue. During the regeneration phase the division of satellite cells are activated. This phase stimulates tissue and muscle growth and repair to ensure the restoration of function<sup>49</sup>. DOMS and impaired muscle function are distinctive characteristics and symptoms of exercise-induced muscle damage<sup>3,6,19,21,38,50–52</sup>.

#### **2.4.2 Delayed onset muscle soreness**

Delayed onset muscle soreness (DOMS) is a typical symptom of exercise-induced muscle damage<sup>49,53</sup>. The understanding is that DOMS is caused by *“damage and inflammation of non-contractile connective tissue, which gives rise to painful sensations when the muscle is palpated, stretched or activated”*<sup>53</sup>. DOMS’s symptoms have been described as an irritation and discomfort, associated with exercise-induced muscle soreness, and is predominantly experienced after lengthening muscle actions<sup>44</sup>. DOMS usually follows a typical course and may include the following characteristic muscular symptoms; functional impairment, cramps, stiffness, and swelling. DOMS usually appears only several hours after a damaging bout of exercise. The symptoms then typically peak between 24-72 hours post exercise and starts to decrease about 96 hours later, but may persist for ten days or longer after intense or unaccustomed exercise<sup>44,53</sup>.

Although DOMS is a symptom of exercise-induced muscle damage the pattern and symptoms of DOMS does not match other muscle damage indicators, such as plasma creatine kinase levels and morphological changes in muscle fibres<sup>49,53–55</sup>. Further discussion of exercise-induced muscle damage and DOMS is beyond the scope of this review. Please refer to a detailed article by Hyldahl and Hubal<sup>56</sup> for more information on exercise-induced muscle damage and DOMS.

#### **2.4.3 Fatigue**

Exercise performance may be limited by fatigue. Fatigue following intense or prolonged training or competition may be attributed to muscular and nervous system function<sup>57</sup>. Two models of fatigue, central and peripheral fatigue are recognised<sup>58,59</sup>. According to these models, fatigue during exercise is caused by chemicals that affect either the muscles or the brain causing central or peripheral fatigue<sup>58,59</sup>.

Peripheral fatigue may be caused by peripheral mechanisms that arise distal to the nerve stimulation site<sup>59</sup>, affecting the muscles or peripheral nervous system. Changes in the muscle excitation-contraction coupling may fail to generate adequate force to maintain the required power and strength, resulting in peripheral fatigue<sup>57,59,60,61</sup>. Peripheral fatigue might also be caused by altered nerve conduction, impaired muscle performance<sup>57</sup> or when there is structural damage or disruption of the myosin or actin<sup>62–65</sup>.

Central fatigue is caused by the brain being fatigued<sup>66</sup>. Byrne et al.<sup>53</sup> explained that symptoms of muscle damage such as muscle soreness and oedema might stimulate nociceptors that would inhibit the muscles via neural pathways leading to decreased performance and central fatigue<sup>53</sup>. It is common that central fatigue may be present for multiple days after a strenuous activity like running a marathon<sup>67</sup>. Millet et al.<sup>68</sup> agreed and attributed the reduction in muscle power and strength after an ultramarathon to the central fatigue mechanism<sup>68</sup>. Baden et al.<sup>69</sup> suggested that fatigue is a subjective experience that is influenced by emotions like anger, fear, and anxiety. These emotions activate neural networks in the brain causing the sense of fatigue<sup>69</sup>. Further discussion of the different physiological models of fatigue is beyond the scope of this review. Please refer to Noakes<sup>70</sup> for more information on the physiological models of fatigue.

#### **2.4.4 Overtraining**

Endurance training programmes need careful planning to ensure that the physiological adaptations and benefits of strengthening and running are gained, while avoiding or minimising the effects of fatigue and exercise-induced muscle damage<sup>3,4</sup>. Successful endurance athletes usually train daily. Acute recovery between sessions becomes vital to support these training loads<sup>5</sup> as prolonged or repeated training sessions cause the breakdown of muscle protein, resulting in structural, metabolic and physiological changes<sup>5,6</sup>.

A good training programme must consider multiple important components, including the status of the relevant anatomical structures of the athlete; the nature of the applied stresses or load during exercise; the frequency, intensity and duration of the applied load; and the recovery times and adaptation periods between training sessions<sup>35</sup>.

Athletes often train hard for a specific time, increasing the volume and intensity to build more muscle strength and to improve the resistance to fatigue thereby increasing endurance<sup>50,71-74</sup>. This build-up of training stress results in a short term performance reduction and is called overreaching. The reduction in performance may last several days to several weeks and may be associated with physiological and psychological symptoms<sup>74</sup>. Overreaching may be important for athletes to increase performance. Adequate recovery techniques help to maximise this process. However, when overreaching is undertaken with insufficient recovery time, it may lead to increased fatigue and reduced performance causing overtraining. Overtraining is the result of accumulation of training that cause a long term performance reduction<sup>50,71-74</sup>.

Overreaching can be divided into functional overreaching, non-functional overreaching, or overtraining syndrome<sup>71,74</sup>. Overreaching is defined as the accumulation of all exercises, competitive or in training, causing a short-term decrease in performance. It may take several days to recover and restore the performance capability. Functional overreaching is considered to be normal and part of the training and competition process. Non-functional overreaching is abnormal and results in the dysfunction of the physiological, biochemical and psychological systems in the body<sup>71,73,74</sup>. Overtraining or the overtraining syndrome is a chronic overtrained state that causes physical, emotional and behavioural symptoms that can last for weeks to months<sup>72</sup>. Unfortunately, non-functional overreaching and the overtraining syndrome are very common. Between 15 to 50% of competitive endurance runners can suffer from non-functional overreaching in a season due to overtraining and insufficient recovery processes<sup>72</sup>. Finding a balance between training, competition and recovery is thus a major challenge<sup>71,72</sup>.

#### **2.4.5 Running-related injuries**

The reported yearly incidence of running-related injuries is approximately 60%, although when training for a marathon (42.2 km) this incidence can increase to as much as 90% as a result of the increase in training frequency and distance<sup>75,76</sup>. Van Gent et al.<sup>77</sup> reviewed running injury studies and reported a 26% to 92% incidence of injury in runners. Approximately 80% of injuries occurred at or below the knee<sup>77,78</sup>. Common injuries included stress fractures, shin splints, low back pain, patella-femoral pain syndrome and tendinopathies<sup>79</sup>. The exact incidence and prevalence of injuries is difficult to determine as many studies rely on retrospective self-reporting questionnaires, which may lead to a poor recall of the details relating to the injuries.

## 2.5 RECOVERY

The intense, stressful training programmes required for endurance running at both recreational and elite levels may result in exercise-induced muscle damage, DOMS and fatigue<sup>80</sup>. Cheung et al.<sup>81</sup> proposed that exercise-induced muscle damage and DOMS may be associated with changes in muscle function and joint mechanics, together with higher levels of fatigue, which may predispose the athlete to injury. Furthermore, Barnett<sup>80</sup> suggested that a lack of full recovery from exercise-induced muscle damage and DOMS may lead to an inability to train at the required intensity, or to complete the required load at subsequent training sessions, and increased fatigue. These factors may therefore adversely affect exercise performance during both training and competition<sup>80</sup>.

It is therefore essential that an appropriate balance between training and competition stresses and recovery is achieved to maximise the performance of athletes<sup>80,82</sup>. Consequently, a training programme should include adequate recovery to facilitate maximal effectiveness of the training intervention. It is also important that the athlete should rapidly recover from such musculoskeletal damage as this may accelerate adaptation to exercise, and facilitate a more rapid return to training, thereby enhancing competitive performance<sup>82</sup>.

Recovery may be defined as the return of the muscle to its pre-exercise state following intensive or prolonged training<sup>13</sup>. From the perspective of endurance runners, recovery may be defined as the point at which the runner is able to train without constraints of sore muscles or an increased risk of injury. The purpose of the recovery process is to correct metabolic and mechanical disturbances in the body following exercise-induced muscle damage. Viru<sup>83</sup> identified the main functions of the recovery period as *“normalisation of function; normalisation of homeostatic equilibrium; replenishment and temporary super compensation of energy resources and reconstruction”*<sup>83</sup>.

After unaccustomed exercise, metabolic changes occur in the muscle, including an increase in lactic acid, hydrogen ion concentration, a decrease in plasma pH and an impairment of muscle contractility<sup>80</sup>. This ultimately results in skeletal muscle fatigue and decreased exercise performance<sup>84</sup>. Further research has suggested that a plasma acidosis, following high performance exercise may impair central nervous system (CNS) drive to skeletal muscle, leading to decreased exercise performance in athletes following exercise-induced muscle damage<sup>80,84</sup>.

Muscle glycogen concentrations decrease with exercise and continue to decrease even after exercise has ended, particularly when muscle damage occurs. Muscle glycogen levels return to pre-exercise levels within 24 hours after the exercise stimulus, provided there is no associated exercise-induced muscle damage<sup>80,84</sup>.

Muscles that have previously been exposed to lengthening muscle actions have a reduced rate of glycogen storage due to competition between inflammatory and muscle cells for available glucose<sup>85</sup>. After exercise-induced muscle damage, intramuscular glycogen levels may take up to ten days to be restored. During exercise that results in a reduction in muscle glycogen concentrations, the load attainable by the athlete in the next training session may be limited by the post-training glycogen synthesis that is required. The restoration of pre-exercise muscle glycogen levels it is therefore important to enhance muscle function and accelerate the recovery process<sup>80</sup>.

During high intensity exercise, metabolic changes occur such as an increase in lactate and hydrogen ion concentrations within the muscle. These increases have been associated with fatigue. Lactic acid causes a reduction in muscle pH leading to acidosis, which may be detrimental to exercise performance, due to associated inhibition of the contractile properties of muscle. A more recent theory suggests that muscle fatigue following high-intensity exercise may be due to a down-regulation by the central nervous system, which impairs muscle function<sup>84</sup>. In particular, after eccentric exercise, the pre-activation of the muscle decreases and results in a reduction in force output proportional to the degree of exercise-induced muscle damage<sup>86</sup>.

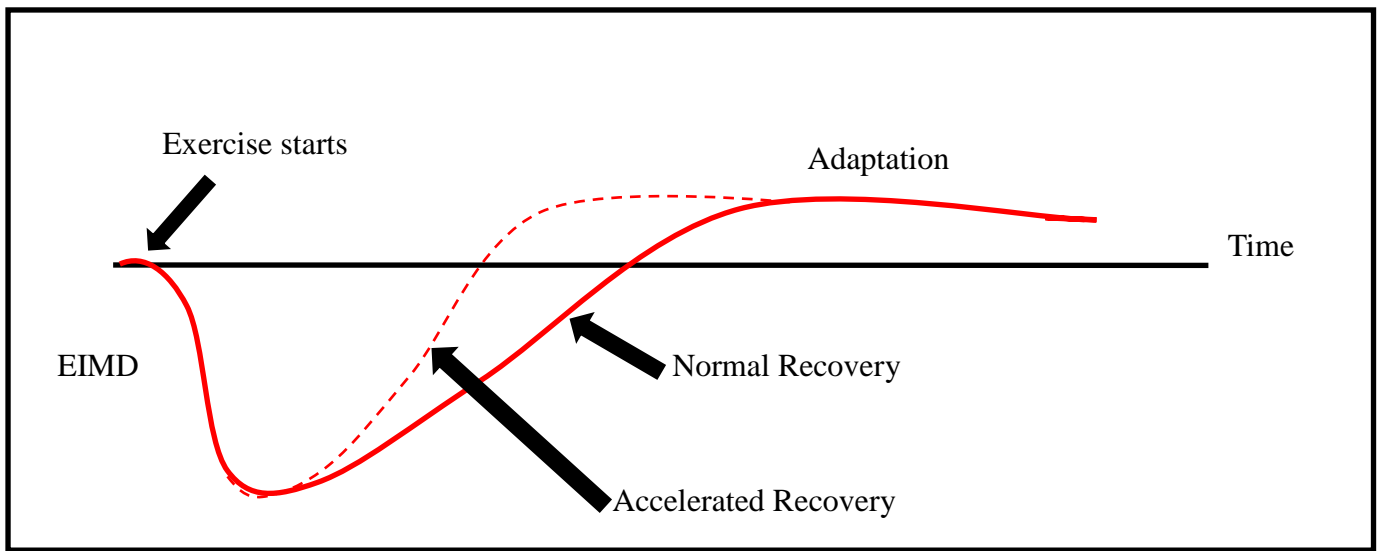
Recovery must therefore restore all the physiological and psychological resources of the body<sup>71</sup>. The recovery process includes the activation of satellite cells; the formation of new red blood cells and other cellular components; the restoration of nutrition, particularly blood glucose levels and glycogen stores; and the replenishment of electrolytes and fluids lost during exercise<sup>13,5,6</sup>.

It is evident that there are numerous physiological adaptations to endurance running training, and that many of the adaptations may adversely influence exercise performance. A recovery period is therefore essential to restore homeostasis following intense or prolonged endurance running training or competition<sup>87</sup>.

Due to the nature of endurance running, athletes have intensive training schedules and regularly participation in races. To ensure rapid and optimal return to training and competition, recovery should be a carefully planned process that facilitates functional overreach and positive training adaptations<sup>13,31</sup>. Therefore utilising modalities that assist with recovery are crucial to enable athletes to maintain performance when optimal time for recovery may not be feasible<sup>50</sup>.

## 2.6 RECOVERY MODALITIES

Although recovery has been described as a passive process, many modalities have been developed that attempt to accelerate the rate of recovery. Recovery modalities are techniques used by athletes to increase the rate and quality of their recovery after competition or training<sup>9</sup>. The principle of accelerated recovery<sup>88</sup> is illustrated in Figure 2-1.



**Figure 2-1: Principle of Recovery (Adapted from Rushall & Pyke<sup>88</sup>)**

A planned recovery process may include different recovery modalities, where each has a specific goal during the recovery process. Recovery strategies should be based on individual requirements, and should consider the training history, severity of fatigue, and ability to cope with stress<sup>9</sup>. Recovery modalities include nutritional substances, such as protein, carbohydrates and vitamins, to replace depleted glycogen stores and to assist with muscle and tissue healing. Recovery modalities may also include other activities and techniques for example light exercises (or active recovery), stretching, massages, compression garments, cryotherapy, different types of water immersion, or complete rest to enable the body to recover quickly<sup>13,21,31,71,89-93</sup>. Unfortunately, scientific evidence for the effectiveness of different recovery modalities is limited. Table 2-1 (page 23-24), Table 2-2 (page 30-32) and Table 2-3 (page 39-40) provide summaries of the trials that have examined the efficacy of different recovery modalities as well as an indication of the level of evidence of these trials.

The following sections will review the proposed physiological mechanisms and strategies for use of different recovery modalities; and current evidence to support the use of each modality will be discussed.

## **2.6.1 Commonly used recovery modalities**

### **2.6.1.1 *Passive recovery***

#### **a) Proposed physiological mechanism to enhance recovery**

Passive recovery or rest is the natural and most common response by the body when fatigued<sup>2</sup>. During rest, the metabolic and cardiovascular rates slow down. Muscles use less energy as there is less contraction between the sarcomeres<sup>2,5</sup>. In the initial phase of rest after exercise there is an exponential drop in the heart rate due to the restoration of the vagal nerve stimuli and less sympathetic influence, as the parasympathetic system is reactivated<sup>94</sup>.

#### **b) Strategies for use**

Currently there is no evidence for the most advantageous time and frequency to rest for optimal recovery after different exercises. A study monitoring heart rate recovery during different recovery positions after sub-maximal exercise found that the initial heart rate recovery is better in supine compared to in the seated position<sup>94</sup>.

#### **c) Current evidence**

Research on recovery modalities often uses passive recovery in a control group as there is no active treatment or any activity taking place to accelerate or optimise the recovery process<sup>2,5,92</sup>. A Cochrane review by Bleakley et al.<sup>19</sup> evaluated 14 studies that compared cold water immersion with passive recovery. Twelve of these studies measured perceived level of pain on the VAS at 24 hours, 48 hours, 72 hours and 96 hours after exercise. Cold water immersion was associated with a significant reduction in the perceived level of pain at all four points post-intervention. Pooling of secondary outcomes such as power, strength, swelling and other were difficult due to the heterogeneous methodology of the different studies<sup>19</sup>. A randomised controlled trial on 26 professional soccer players compared one hour of passive recovery with one hour of electrical stimulation after exhausting exercise. There were no differences in the muscle damage markers or strength tests between the groups' during the recovery process<sup>22</sup>.

### **2.6.1.2 Active recovery**

#### **a) Proposed physiological mechanisms to enhance recovery**

To warm-down or recover actively after exercise is a commonly used principle. During active recovery in the upright position, more blood is shifted to the lower extremities, activating the muscle pump to increase blood to flow back to the heart and increase ventricular filling. This increases the blood flow to the muscles, with a resultant increase in cell metabolism. Lactate metabolism, replenishing the glycogen stores, and the removal of metabolic by-products are increased, thereby assisting the recovery and adaptation of damaged muscles<sup>17,20,92,94</sup>.

#### **b) Strategies for use**

Active recovery includes any form of exercise done at sub-maximal heart rate. It is recommended to perform the same type of activity as the activity you wish to recover from, for example running or walking for runners. There is no available literature that specifies the most effective timing or duration of active recovery<sup>20,92</sup>.

#### **c) Current evidence**

Randomised controlled trials have shown that active recovery has a better effect on the normalisation of the pH and the blood lactate concentration than passive recovery<sup>17,20,92,95</sup>. One small study comparing passive and active recovery of 12 tri-athletes after a maximal output on a cycle ergometer showed no meaningful differences in hormonal changes between the two recovery modalities. There was, however, a significant increase in the lactate and other metabolic outcomes confirming that active recovery increases cell metabolism<sup>17</sup>. Unfortunately, some of the studies that have investigated the effects of active recovery use cross-over designs, with only two to three days between different interventions. The main disadvantage of these studies is that the symptoms of DOMS only peak at 24 to 72 hours post exercise and can persist for up to ten days. Therefore the outcomes of these studies are questionable because of the large potential of contamination of variables<sup>20,92,95</sup>. Further research is therefore needed to evaluate the effect of active recovery.

### **2.6.1.3 Stretching**

#### **a) Proposed physiological mechanisms to enhance recovery**

Stiff and painful muscles are commonly associated with overtraining and exercise-induced muscle damage. This muscle stiffness can increase immediately after exercise, peaks at around 48 hours and may last for up to three to four weeks<sup>41,47,96</sup>. Overtraining causes structural changes to the sarcolemma due to high mechanical forces that can change the length-tension relation of a muscle<sup>97</sup>.



Stretching a stiff muscle causes changes in the mechanical properties of a muscle possibly leading to faster recovery after exercise-induced muscle damage<sup>97</sup>.

#### **b) Strategies for use**

There is limited scientific evidence available on stretching to aid the recovery process. Stretching prior to activity, and in some cases after activity, is commonly used all over the world to prevent injuries<sup>24</sup>. The perceived effects of stretching include to improve range of motion, to relax the muscles, and to reduce muscle soreness and stiffness<sup>9</sup>. Epidemiology research recommends stretching to increase muscle compliance, as reduced flexibility is a risk factor for muscular injuries<sup>24</sup>.

Recently some contradictory recommendations have been made on the principle that most muscular injuries occur during active, eccentric contraction when the muscle is unable to control sarcomere lengthening. The ability of the muscle to control lengthening during activity might thus be more important than the passive compliance that stretching can achieve. When a muscle is fatigued the contractile ability, as well as the ability to resist lengthening of the sarcomeres, is reduced. A fatigued muscle has been shown to have a reduced ability to absorb energy and is at higher risk for injuries<sup>24</sup>. Bieuzen et al.<sup>32</sup> conducted a literature review of studies comparing contrast water immersion with various other recovery modalities, such as stretching. They found that the quality of the studies was very low and recommended better quality research be undertaken. However, based on the current available research, it was recommended that it might be safer to rather perform prolonged stretching to increase muscle length, outside of the pre-exercise warm-up period<sup>32</sup>.

Weldon et al.<sup>24</sup> conducted a systematic review to evaluate the effect that stretching has on injury prevention. Two studies in their literature review found that endurance runners have significantly stiffer hamstring muscles than normal individuals. They attributed this muscle stiffness to the number of cross-links in the sarcomere of the muscle, which is unlikely to be influenced by passive stretching of the muscle. The literature review found that the quality of the randomised controlled trials was very low and no definite conclusion could be made on the outcome of the studies. There was some evidence to suggest that pre-exercise stretching should be done carefully to avoid over stretching. Over stretching can lower the pain threshold of a muscle and has been associated with increased muscular fatigue<sup>24</sup>.

### **c) Current evidence**

There is limited literature available on the effect of stretching on recovery. There are two Cochrane reviews by Herbert et al.<sup>96</sup>. The first in 2007 located 10 relevant randomised trials looking at the effect of stretching before or after physical activity on muscle soreness. The trials were mostly small and of questionable quality. Nine were conducted in laboratories using standardised exercises. Only one study examined the effect of stretching on muscle soreness after sport. Three of the studies examined the effects of stretching before physical activity and seven examined effects of stretching after physical activity. The 10 studies produced very consistent findings. They showed there was minimal or no effect on the muscle soreness experienced between half a day and three days after the physical activity. Effects of stretching on effect on other outcomes such as injury and performance were not examined in this review<sup>96</sup>. The second review in 2011 included two new studies, one of which was a large randomised trial. The conclusion of the second review remained the same as the first review. Although stretching reduces soreness after exercise-induced muscle damaged, the effect is very small<sup>96</sup>. Torres et al.<sup>98</sup> have conducted a meta-analysis of nine randomised control trials, evaluating the effects of stretching on recovery. The studies used different stretching protocols, including stretching before-, after- and repeatedly after exercise. Stretching had no significant effects on the recovery process, regardless of when and how the stretching was applied<sup>98</sup>. Weldon et al.<sup>24</sup> also found that the quality of the available studies was very low, with only two good studies. Both of these studies showed no significant effect of stretching on injury prevention<sup>24</sup>. Another low-quality randomised controlled trial that compared the effect of contrast temperature water immersion with stretching after prolonged exercise also showed no differences in outcome between the two modalities when comparing creatine kinase, muscle soreness, muscle strength and muscle power<sup>32</sup>. There is thus a need for better quality randomised controlled trials to determine the role of different types of stretching during recovery<sup>24</sup>.

#### **2.6.1.4 Anti-inflammatory medication**

##### **a) Proposed physiological mechanisms to enhance recovery**

Athletes all over the world use analgesics or non-steroidal anti-inflammatory drugs (NSAIDs) regularly to decrease pain, assist with recovery, and to accelerate their return to sports. NSAIDs are often used as a preventative modality and have potential to improve performance. NSAIDs work by blocking cyclooxygenase activity and inhibiting pro-inflammatory prostaglandin synthesis. NSAIDs have an inhibitory effect on the initial inflammatory response, influencing the function of the macrophage and neutrophils. NSAIDs can therefore impair the repair process of the body as they change the natural healing process after an injury<sup>23,99,100</sup>.

### **b) Strategies for use**

NSAIDS can be administered orally, via an intramuscular injection, or topically<sup>23,99,100</sup>. Although NSAIDS may reduce pain and improve function after an acute injury, they may cause multiple harmful side effects that are often overlooked to achieve the short-term goal of decreased pain and increased recovery. Despite the side effects, NSAIDS are still widely used. Regular use of NSAIDS may lead to adverse effects of the gastrointestinal system. NSAIDs can also cause dehydration and liver and kidney disorders<sup>23,99-103</sup>. There is good evidence for the effective use of NSAIDS in pain relief over the short term, but as they are not much more effective than paracetamol, it is recommended that they are only used when justified, after a 48 hour period post injury. The minimal effective dose for the shortest amount of time should then be prescribed<sup>23,100,104</sup>. The use of paracetamol instead of NSAIDS is recommended in the initial 48 hours after an injury to promote adequate tissue healing<sup>100,103</sup>. Use of NSAIDS during sporting events is not recommended, due to their adverse effects on soft tissue healing and the other multiple side effects previously mentioned<sup>23,100,101,103</sup>.

### **c) Current evidence**

Several studies have described the use of anti-inflammatory medication by sports persons in various sports<sup>23,101-103</sup>. Tscholl et al.<sup>102</sup> combined the information that the 2002 and 2006 team physicians of the FIFA World Cup soccer tournaments gave the doping control centre. The physicians were asked to report all medication used by players in the 72 hours before each match. They found that more than 50% of all soccer players took NSAIDS at least once during the tournament and that it was the most prescribed medicine reported<sup>102</sup>. A similar trend was reported for the 2000 Sydney Olympic Games. Canadian athletes were reported to have used NSAIDS more frequently than any other medication<sup>23</sup>. During the 1996 African Nations Cup, 31% of soccer players used NSAIDS in the form of an injection in the 72 hours prior to a match<sup>103</sup>.

The use of NSAIDS by American high school football players was also very high. From a sample of 681 players, 75% reported in a questionnaire that they had used NSAIDS during the last three months for sports-related reasons. Fifteen percent of these high school football players used NSAIDS daily as a prevention measure to block pain before it occurred. In most cases the players self-administered the medication and self-prescribed the dose<sup>101</sup>.

Topical application of NSAIDS is attractive as it can provide pain relief without the systemic adverse side effects. Topical NSAIDS can be applied in the form of gels, sprays, cream or patches<sup>103,105</sup>. A Cochrane Review by Massey et al.<sup>105</sup> examined 47 randomised controlled trials comparing various types of topical applications of NSAIDS against those of placebos. They found that the topical NSAIDS offered significant pain relief for acute pain compared to the placebos. There was no real difference in outcome between different types of topical NSAIDS, such as diclofenac, ibuprofen, ketoprofen and piroxicam and the side effects reported were not significantly greater than those for the placebos<sup>105</sup>. A literature review of studies comparing topical diclofenac and ketoprofen patches with NSAIDS cream against placebos found that both types of patches were well tolerated. The NSAIDS patches gave significantly better pain relief compared to the placebos and the NSAIDS cream but neither accelerated the return to sport<sup>23</sup>. Another review which focussed on the topical application of diclofenac reported similar results<sup>106</sup>. These literature reviews found that the topical NSAIDS were well-tolerated with few systemic adverse effects<sup>23,105,106</sup>.

#### **2.6.1.5 Massage**

##### **a) Proposed physiological mechanisms to enhance recovery**

Massage is widely used and can include a variety of different techniques. Massage might increase blood circulation as is evident by hyperaemia of the skin during and after a massage<sup>25</sup>; although recent research has shown that massage does not cause a change in blood flow below the surface of the skin<sup>80</sup>. Massage can decrease the inflammatory response, muscle spasm and adhesions, resulting in muscle relaxation and improved flexibility and range of motion<sup>20,95,107</sup>.

##### **b) Strategies for use**

Massage is commonly used before and after training and races as a recovery modality. Massage has a psychological effect, lowering stress levels and creating a feeling of well-being, which contribute to recovery<sup>20,25,95,107</sup>.

##### **c) Current evidence**

Torres et al.<sup>98</sup> performed a systematic review of nine randomised control trails assessing the effect of massage after exercise-induced muscle damage. Most studies lacked high methodical quality and effective blinding. Six of the studies showed that massage had a positive effect on perceived muscle soreness, and three studies found that massage had a positive effect on muscle strength<sup>98</sup>. There were only sufficient data between all the studies for meta-analyses at 24 hours after activity. The results indicated that massage reduced muscle soreness, measured on a 10 cm VAS, significantly at 24 hours after exercise-induced muscle damage<sup>98</sup>.

Hopper et al.<sup>72</sup> tested hamstring flexibility before and after an eight-minute sports massage on 39 hockey players. Although they found significant changes in flexibility these changes were not maintained for more than 24 hours<sup>72</sup>. Brummit<sup>25</sup> reviewed randomised controlled trials, quasi-experimental trials and case reports that investigated the effect of massage on recovery after exercise. It was concluded that massage has an effect on blood pressure and that massage techniques, such as effleurage and petrissage, can lower blood pressure, while a deep sports massage may cause an increase in blood pressure. In the review, massage showed no significant results on the metabolic substances, such as lactate, glucose or creatine kinase levels compared to active recovery or passive recovery<sup>25</sup>. Hilbert et al.<sup>26</sup> compared the effect of 20 minutes of massage on DOMS against the use of a placebo, where massage oil was applied and followed by 20 minutes of rest. Although participants experienced less muscle soreness in the massage group, there were no significant differences in muscle function or flexibility between the groups<sup>26</sup>.

These findings have been confirmed by other studies that examined the effect of massage on recovery after endurance or intense exercise. In these studies massage did not influence plasma creatine kinase or lactate dehydrogenase concentrations or isokinetic strength tests outcomes. However, massage had a positive effect on perceived muscle soreness 12 to 24 hours after exercise<sup>20,80,95,107</sup>. Unfortunately, some research studies on massage as a recovery modality are cross-over design studies, with only two to three days between interventions. As DOMS only peaks at 24 to 72 hours post exercise, the outcomes of these studies might be unreliable due to contamination of the variables<sup>20,95</sup>.

There is therefore currently insufficient physiological evidence to support the use of massage as a recovery modality. It might still be regarded as useful for the psychological benefits to the athlete<sup>80</sup>.

#### **2.6.1.6 Compression garments**

##### **a) Proposed physiological mechanisms to enhance recovery**

Compression garments are available in different shapes and sizes, from full body suits to socks covering only the lower legs. There is very little evidence to support the use of compression garments in facilitating recovery after exercise. Compression garments are thought to increase circulation by assisting the muscle pump action mechanism. This improves the removal of metabolites, increases tissue oxygenation, and decreases oedema. Thus compression garments may reduce muscle pain and fatigue, and improve range of motion<sup>20,108</sup>.

### **b) Strategies for use**

Most literature recommends the use of gradual compression garments that may possibly be effective in assisting the normal physiological venous flow from ankle to the heart without resulting in a tourniquet effect. Compression garments should be worn immediately after strenuous or prolonged exercise to improve recovery, but the ideal duration for wearing these garments has not yet been established<sup>20,108</sup>.

### **c) Current evidence**

A randomised controlled trial compared the use of a graduated compression sock with a placebo sock in 40 athletes during and for 72 hours after running a 56 km marathon. The group wearing the graduated compression sock had less pain and oedema in their calves and quadriceps muscles after the race compared to the control group, but there were no significant differences in plasma creatine kinase concentration and C-reactive protein levels between groups<sup>20</sup>. Hill et al<sup>109</sup> conducted a randomised control trial with 24 athletes. The participants completed a marathon, after which they were divided in two groups. The one group wore lower limb compression tights for 72 hours after the marathon while the sham group received one treatment of 15 minutes of sham ultrasound after the race. Although there were no significant improvement in muscle damage or inflammation markers between the groups, the group that wore the compression garments reported significant improvements in perceived muscle soreness compared to the sham group<sup>109</sup>. Jakeman and Byrne<sup>107</sup> observed the same reduction in perceived muscle soreness with no improvement in muscle damage or inflammation markers after the use of compression stockings in a cross-over study design on 32 female volunteers. Wearing compression stockings for 12 hours immediately after plyometric exercise was compared with the effect of 30 minutes massage immediately after plyometric exercise and a combination of 30 minutes massage and wearing compression stockings for 11.5 hours after exercise. The combination of massage and compression stockings showed significantly reduced level of perceived muscle soreness at 48 and 72 hours after activity compared to the other groups<sup>107</sup>. More high quality research is needed to establish the effect of compression garments during the recovery process.

#### **2.6.1.7 Heat application and hot water immersion**

### **a) Proposed physiological mechanisms to enhance recovery**

Heat causes peripheral vasodilatation, increasing the blood flow to the region, enhancing the removal of metabolic by-products, and assisting in maintaining the neuromuscular performance of the body<sup>20,21</sup>.

**b) Strategies for use**

Heat can be applied through a number of different techniques of which a pre-heated pack or hot water, for example, a warm bath or shower, are the most practical options<sup>21</sup>. There is no literature available to determine the optimal duration and temperature of heat applications to speed up the recovery process.

**c) Current evidence**

Temperate water immersion has not been well-researched as a recovery method. Studies comparing treatment of cold water immersion<sup>32</sup> or contrast temperature water immersion with temperate water immersion after intense exercise, found that cold water immersion and contrast temperature water immersion had better outcomes<sup>21,110</sup>. Moore et al.<sup>110</sup> compared treatment with cold water immersion, hot water immersion and passive recovery on eleven well-trained athletes, after a 90-minute shuttle test. Although there was a significant decrease in muscle strength loss after treatment with cold water immersion compared to the temperate water immersion, most participants preferred temperate water immersion above cold water immersion<sup>110</sup>.

**Table 2-1: Summary of studies for passive recovery, active recovery massage and compression.**

<b>Type of recovery modality</b>	<b>Study design and level of evidence</b>	<b>Participants and sample size</b>	<b>Exercise protocol</b>	<b>Intervention</b>	<b>Outcomes</b>	<b>Conclusion</b>
<b>Passive and active recovery</b> <b>Barak et al.</b> <sup>94</sup>	Randomised controlled trial. Level of evidence 2 Pedro 6	24 well-trained male athletes and 19 sedentary male students.	5 minute sub maximal cycling at 80% peak heart rate.	Active recovery, continued cycling but with no workload. Passive recovery: Upright seating. Supine, flat on back. Supine with legs elevated.	No correlation between peak power and heart rate. Supine heart rate recovery was better than seated. Active recovery had a slower heart rate recovery. Heart rate recovery was faster in athletes than sedentary group.	Supine position showed best heart rate recovery rates.
<b>Passive recovery</b> <b>Bieuzen et al.</b> <sup>22</sup>	Randomised controlled trial. Level of evidence 2 Pedro 6	26 professional male soccer players, volunteers.	Intermittent fatiguing exercise protocol.	1 hour recovery consisting of either passive recovery or on an electric blood flow stimulator.	No differences between groups in muscle damage markers, maximal counter jump or contraction. Electric stimulation group showed better 30 seconds performance after 1 hour.	1 hour post exercise the electric stimulation group showed improved performance vs the passive recovery group.
<b>Active recovery</b> <b>Wahl et al.</b> <sup>17</sup>	Randomised cross over study one week apart. Level of evidence 2 Pedro 7	12 healthy tri-athletes or cyclists.	Four 30 seconds maximal effort cycling on ergometer separated with 7 or 5 minutes of recovery and 10 minute recovery at the end.	Active cycling at 45% peak power output. Resting seated on the cycle ergometer.	Total work, heart rate, oxygen consumption and energy expenditure was higher during active recovery. Rate of perceived exertion was the same. No differences in acute hormone response.	No difference in the acute hormone response between active and passive recovery. Active recovery showed an increase metabolic effect.
<b>Massage</b> <b>Hilbert et al.</b> <sup>26</sup>	Randomised control trial. Level of evidence 2 Pedro 6/10	18 Volunteers Male and female.	10 maximal eccentric contractions of the right hamstring. 6 sets followed by 1 minute rest.	20 min massage two hours post exercise. Placebo: application of oil and then rest for 20 minutes.	POMS questionnaire that evaluate the mood state. Hamstring range of motion. Peak torque.	Decrease in muscle soreness in massage group. No other significant difference between groups.



Table 2-1 continues: Summary of studies for passive recovery, active recovery massage and compression.

Type of recovery modality	Study design and level of evidence	Participants and sample size	Exercise protocol	Intervention	Outcomes	Conclusion
<b>Passive, active recovery and massage.</b> <b>Monedero &amp; Donne<sup>95</sup></b>	Cross over design Level of evidence 2 Pedro 5/10	18 trained male cyclists, volunteers.	5 km maximal effort simulated time trial on a treadmill.	Passive recovery. Active recovery at 50% of $VO_2^{max}$ . Massage. Combined active recovery and massage. But only 2-3 days between applications of different variables.	No performance difference. Maintenance of effort was significantly better for the combination group.	The combination of massage and active recovery possibly better than other.
<b>Passive recovery compression, massage.</b> <b>Jakeman et al.<sup>107</sup></b>	Randomised clinical trial. Level of evidence 2 Pedro 7/10	32 females, untrained, volunteers.	100 plyometric drop jumps.	Three groups. Passive recovery. Compression group wearing compression stockings for 12 hours after activity. Combo group with 30 minutes of massage and compression stockings after activity.	Perceived soreness significantly better in combo group. Minimal differences were observed between groups in plasma creatine kinase concentration, isokinetic strength and squat jumps.	All three groups showed significant improvements after the recovery strategies but with no differences between the groups.

## **2.6.2 Nutritional recovery modalities**

Adequate nutrition is recommended for the body to function optimally during sporting activities<sup>3</sup>. Multiple factors play a role in determining adequate nutrition. These factors include the type of exercise, duration and intensity, the level of training, gender, and the nutritional and hydration status of an athlete<sup>6,12</sup>. As a rule, exercise lasting for longer than one hour requires additional nutritional considerations<sup>111</sup>.

### **a) Proposed physiological mechanisms to enhance recovery**

Nutrition influences the performance of athletes, especially endurance athletes, as they require higher energy levels to replace glycogen stores and extra protein to ensure adequate muscle protein turnover<sup>6</sup>. Adequate energy intake during prolonged or intense training is necessary to avoid loss of muscle mass and bone density, menstrual dysfunction, fatigue, illness and prolonged recovery<sup>111</sup>. To enhance recovery, re-synthesis of muscle and liver glycogen as well as a net protein balance, is important<sup>6,112</sup>.

Endurance athletes utilise mostly carbohydrates and fat as fuel during exercise, but one to six percent of energy is derived from amino acids. When carbohydrates become depleted during endurance exercise, amino acids become more important as fuel<sup>12</sup>. To improve recovery, it is recommended that protein be consumed to repair and build muscles; fluid intake is optimal to ensure normal electrolyte balance; and that there is carbohydrate replacement to replenish muscle glycogen. Gels, bars and sports drinks are dietary supplements that are convenient nutritional supplements for athletes<sup>111</sup>. Personal nutritional guidance may be beneficial to ensure adequate energy sources and that an individual athlete's nutritional requirements are identified<sup>33</sup>.

### **2.6.2.1 Protein**

#### **a) Strategies for use**

Protein is an important source of energy. Protein breakdown increases during exercise, while protein synthesis increases directly after exercise<sup>111,113</sup>. Optimal protein intake should be between 0.8 to 1.8 g.kg<sup>-1</sup> of body weight. Approximately 0.8 g.kg<sup>-1</sup>.day<sup>-1</sup> is enough protein for a non-exercising male older than 19 years, but may be insufficient to support the protein and amino acid oxidation required during exercise or for adequate repair of muscle after exercise. Insufficient intake of protein can create a negative nitrogen balance causing increased catabolism and impaired muscle repair during recovery<sup>11</sup>. The International Society of Sports Nutrition and most of the other literature recommend protein intake of 1 g.kg<sup>-1</sup> to 1.6 g.kg<sup>-1</sup> per day for endurance exercise, depending on the fitness of the athlete and the duration and intensity of the training programme<sup>11</sup>.

As the intensity and duration of a training programme increase, the oxidation of branched-chain amino acids will increase, creating an additional need for protein to ensure performance and optimal recovery<sup>11,12,111</sup>. In a literature review, Tarnopolsky<sup>12</sup> establish that protein intake below 1 g.kg<sup>-1</sup>.day<sup>-1</sup> was insufficient for endurance athletes. Using all the retrospective data from the reviewed studies on average to elite athletes and accounting for inter-individual differences, they calculated that about 1.11 g.kg<sup>-1</sup>.day<sup>-1</sup> of protein is required. The review also confirmed that no extra protein supplements are required for recreational athletes performing low- to moderate training on a normal balanced diet<sup>12</sup>.

Some popular beliefs are that the chronic intake of increased amounts of protein is harmful to the kidneys and could cause renal failure; or that it increases the risk of osteoporosis, as a high protein diet can increase the excretion of calcium. Both these beliefs are unfounded as there is no evidence of harmful effects in ingesting high amounts of protein in a healthy, active person<sup>11</sup>. Different sources of protein are milk, whey, egg, soy and casein, with whey and casein being the most popular. Whey protein is metabolised more rapidly compared to casein. Supplementary protein is available in different forms, with powder as the most convenient<sup>11</sup>. There is no also evidence that amino acid or protein supplements are more or less efficient for athletes than a normal diet<sup>111</sup>.

#### **b) Current evidence**

Amino acids are the building blocks of protein. It would seem that amino acid supplementation could increase protein synthesis and decrease protein degradation. When taken with glucose it can assist with glycogen synthesis. Earlier studies showed that amino acid supplementation during endurance training can decrease plasma creatine kinase and lactate dehydrogenase concentrations and thus reduce muscle damage<sup>50</sup>.

In a study investigating the effects of amino acid supplementation on four weeks of overreaching in 17 weight-trained men, amino acid supplementation decreased the initial reduction in muscle strength normally found during overreaching. In addition, amino acid supplementation had no additional effects when compared to a placebo group when training volume and intensity was decreased. Therefore it was concluded that supplementation of amino acids seemed effective in reducing the initial strength loss associated with overreaching, but that it had no effect during normal training<sup>50</sup>. Research on the optimal timing of protein intake around exercise has mostly focussed on resistance exercise. Increased levels of amino acids in the blood after resistance training have been shown to be beneficial in muscle protein synthesis<sup>11,112</sup>.

A protein source, rich in amino acids and easily digested, taken immediately after exercise, has been shown to increase muscle mass, assist in recovery, and boost the immune system<sup>11,112</sup>. More investigations are necessary to access the optimal timing of protein intake for endurance training<sup>11</sup>.

Gain et al.<sup>113</sup> evaluated the effect of increased protein intake on the nitrogen balance and oxidation. They found that the highest level of protein intake resulted in high levels of protein oxidation, nitrogen balance and protein breakdown, measured by the leucine Ra, an amino acid. It was further found that exercising for about two hours, can increase the oxidation of leucine. Daily training at high intensities can increase the required amount of leucine to prevent a negative nitrogen balance. They found that on a higher protein diet of 1.2 g.kg<sup>-1</sup>.day<sup>-1</sup> there was a better nitrogen balance<sup>113</sup>. Most authors recommend about 1.2 g.kg<sup>-1</sup>.day<sup>-1</sup> of protein for endurance athletes<sup>33,113</sup>.

Muscle growth and repair requires protein. There are contradictory outcomes on whether adding protein to carbohydrates increases glycogen stores<sup>33</sup>. The addition of more protein to a diet does not appear to influence performance levels. Consuming protein during the recovery phase increases the synthesis of muscle protein. Unfortunately, there is a significant delay in protein synthesis in aging athletes. The timing of the protein intake post exercise is irrelevant<sup>33</sup>. About 20 g of protein maximally stimulates fractional protein synthesis. Protein synthesis has been found to increase during high intensity training compared with low intensity or prolonged exercise sessions. There is some evidence that protein intake after exercise may decrease creatine kinase levels<sup>33</sup>. The American College of Sports Medicine (ACSM) recommends that 0.8 to 1.0 g.kg<sup>-1</sup>.h<sup>-1</sup> protein be taken within 30 minutes post training or competition to enhance muscle repair<sup>4,33</sup>. The International Society of Sports Nutrition (ISSN) recommends that athletes take 8 to 10g of carbohydrate per kilogram, together with additional protein to improve glycogen storage<sup>33</sup>.

#### **2.6.2.2 Carbohydrates and glycogen**

##### **a) Strategies for use**

Glycogen is the primary fuel source for intermittent high intensity exercise or sub maximal exercise such as endurance exercise or repetitive resistance exercise<sup>6,33</sup>. Carbohydrates maintain the blood glucose levels during exercise. Depending on an athlete's training programme and daily energy expenditure, between 6 g.kg<sup>-1</sup>.day<sup>-1</sup> to 10 g.kg<sup>-1</sup>.day<sup>-1</sup> of carbohydrate is recommended<sup>111</sup>.

Carbohydrate loading has been around for many years and is one method that is used to ensure adequate glycogen stores. Carbohydrate loading can consist of a low-carbohydrate diet while training for a week and then switching to a high-carbohydrate diet, combined with rest, for three days prior to competition<sup>6,33</sup>. More recent research has shown that the low-carbohydrate diet is unnecessary and that only three days of high-carbohydrate intake is necessary prior to competition to ensure sufficient glycogen stores. Research has also demonstrated that it is possible to replenish the glycogen stores in 24 hours<sup>14,33</sup>. Glycogen synthesis is higher when carbohydrate is consumed directly after exercise, compared to two hours later<sup>33</sup>. A high glycaemic index carbohydrate stimulates greater muscle glycogen storage<sup>33</sup>. It may be more beneficial to take glucose or sucrose rather than fructose as they stimulate a higher rate of muscle glycogen than fructose<sup>33</sup>. The frequency at which the carbohydrate is consumed or its form does not seem to matter<sup>33</sup>.

#### **b) Current evidence**

Strenuous and prolonged exercise both suppresses and stresses the immune system, stimulating the production of pro-inflammatory cytokines such as interleukin-6<sup>14,114</sup>. Robson-Ansley et al.<sup>14</sup> conducted a randomised, cross-over study on nine male athletes to investigate the effect of carbohydrate on plasma interleukin-6. They compared drinking 2 ml.kg<sup>-1</sup> of an 8% carbohydrate solution with drinking a placebo, matched for taste. The athletes drank the solution pre-exercise and then for every 20 minutes during the 120-minutes treadmill run. They found that initially the interleukin-6 was significantly decreased in the group drinking the carbohydrate solution compared to the placebo group, but the interleukin-6 in the carbohydrate solution group and the placebo group returned to baseline after 24 hours. Thus a high carbohydrate diet and ingesting carbohydrates during exercise have an initial effect after exercise, lowering the pro-inflammatory cytokine interleukin-6, but without a significant long-term effects<sup>14</sup>.

### **2.6.2.3 Vitamins and minerals**

#### **a) Proposed physiological mechanisms to enhance recovery**

Vitamins and minerals are small organic compounds that catalyse biochemical processes in the body. Although vitamins and minerals are consumed in small amounts they are vital to regulate the health and function of a body<sup>15</sup>. Vitamins can be classified as water- or fat-soluble. Important water-soluble vitamins are vitamin C and vitamin B. Vitamin B regulates carbohydrate, fat and protein synthesis and degradation. Therefore vitamin B plays a role in energy metabolism<sup>16</sup>. Vitamin C has an effect on the recovery process after intense training and acts as an antioxidant. It can boost the immune system. Vitamin C deficiency can increase fatigue and reduce energy<sup>16,115</sup>.

Intense or endurance exercise can cause temporary immune-depression in athletes, making them prone to infections such as upper respiratory tract infections<sup>115</sup>. Vitamin A, vitamin D and vitamin E are fat-soluble vitamins. They have an indirect influence on energy metabolism. Vitamin A and vitamin E help with reducing muscle damage and supporting recovery after exercise<sup>16</sup>. Vitamin D may have an influence on the regulation of anti-inflammatory cytokine production. Pro-inflammatory cytokines such as interleukin-1 $\beta$  assist with reduction of inflammation and the repair process. However, an excess of pro-inflammatory cytokines can have a detrimental effect on cellular homeostasis. Thus the production of anti-inflammatory cytokines such as interleukin-19 and interleukin-13 is important to control the production of pro-inflammatory cytokines. Vitamin D may influence the production of the anti-inflammatory cytokines<sup>116,117</sup>. Vitamin D plays an important role in skeletal muscle function. Therefore an insufficiency in vitamin D can predispose a person to soft tissue injuries<sup>116,117</sup>. Magnesium supports a number of diverse physiological systems including glycogen, fat and protein metabolism. Magnesium deficiency may potentially limit human performance<sup>16</sup>.

#### **b) Strategies for use**

Athletes often use mineral and vitamin supplements; mostly to compensate for inadequate diets, to provide extra nutrients and energy during intense training programmes, to aid their performance<sup>16</sup>, or to prevent illness and infection<sup>15</sup>. The recommended daily allowance for magnesium is 320 mg.d<sup>-1</sup> for females and 420 mg.d<sup>-1</sup> for males<sup>16</sup>. Most physically active adults consume an adequate amount of vitamin C. A diet that includes a variety of foods ensures adequate intake of vitamins and minerals thereby eliminating the need for additional vitamin and mineral supplements<sup>16</sup>.

#### **c) Current evidence**

One randomised controlled trial supplemented 600 mg of vitamin C to half of their 92 participants for 21 days prior to running the Comrades Marathon. The other participants formed the placebo group that received a similar looking tablet containing citric acid. Telephone interviews were conducted after running the Comrades Marathon to ask the participants about upper respiratory tract symptoms. Significantly fewer participants that received vitamin C supplements reported symptoms compared to the control group<sup>118</sup>. Contrary to these findings, a literature review found that there was inadequate evidence to show the effect of vitamin C and other macronutrients on upper respiratory infections in endurance runners<sup>115</sup>. A literature review by Lukasi<sup>16</sup> found that most studies reported an increase in muscle strength and performance with supplemental magnesium, but only when an athlete's diet lacked sufficient magnesium<sup>16</sup>.

**Table 2-2: Summary of studies for protein, carbohydrates and vitamins.**

Type of recovery modality	Study design and level of evidence	Participants and sample size	Exercise protocol	Intervention	Outcomes	Conclusion
<b>CHO</b> <b>Chen et al.</b> <sup>119</sup>	Randomised crossover trial. Level of evidence 2 Pedro 3/10	8 male, endurance runners, volunteers.	21km race. First 5km done at 70% $VO^2_{max}$ .	Different meals before race. Low glycemic index meal. High glycemic index with a carbohydrate-electrolyte drink during race. Placebo meal with fat but sugar free in a low calorie jelly.	Race times were the same for low glycemic index, high glycemic index and placebo meals. Interleukin-2 decreased only in CON, but returned to normal 60 min after Interleukin-6 increased after all three meals and was back to normal 60 min post race in after a low glycemic index meal. Blood glucose was high before, improved during race and was 60 minutes post race not back to normal after a high glycemic index meal. No difference in carbohydrate & fat oxidation rate before, during or after activity.	Very small study sample. A pre-exercise low glycemic index meal attenuates an increase in cortisol levels. More research is necessary.
<b>Carbohydrate</b> <b>Hill et al.</b> <sup>6</sup>	Randomised, single blind, crossover study. Level of evidence 2 Pedro 7/10	6 male endurance cyclist and tri-athletes.	70-90% of $VO^2_{max}$ on a cycle ergometer.	Two different diets for 16 days, followed by 4 week wash out before cross over. Carbohydrate diet. Carbohydrate with whey protein isolates sports drink diet.	Time to fatigue no significant difference. Plasma glucose concentration was significantly increased for both groups during and 40-60 min after cycling at 90% $VO^2_{max}$ . Insulin was significantly higher in the carbohydrate with whey protein isolates diet 180min after activity. Muscle glycogen levels were lower in both diets until 6 hours post cycling, but in carbohydrate with whey protein isolates diet it showed an increase immediately post cycling.	Co-ingestion of carbohydrate with whey protein isolates may benefit recovery by an increased insulin response.

Table 2-2 continued: Summary of studies for protein, carbohydrates and vitamins

Type of recovery modality	Study design and level of evidence	Participants and sample size	Exercise protocol	Intervention	Outcomes	Conclusion
<b>Protein</b> <b>Gain et al.</b> <sup>113</sup>	Randomised crossover trial Level of evidence 2 Pedro 6/10	5 male, endurance runners.	Resting	Three different diets: Low protein diet. Moderate protein. High protein diet. Each diet for 3 weeks.	Nitrogen balance for high protein diet significant higher. Protein oxidation increased as protein intake increased. Leucine Ra and oxidation significant lower in low- than high protein diet. Plasma insulin concentration decreased as protein increased in diets.	Protein intake of 1.2 g.kg <sup>-1</sup> or 10% is necessary for a positive nitrogen balance.
<b>Carbohydrate</b> <b>Robson-Ansley et al.</b> <sup>14</sup>	Randomised double blind crossover study. Level of evidence 2 Pedro 5/10	9 males, well-trained, volunteers.	Treadmill runs at 60% VO <sup>2</sup> max for 120 min followed by a 5km trial run.	Consumed two different drinks before and then every 20 min of a treadmill run and at end of trial run. 2ml.kg <sup>-1</sup> of an 8% carbohydrate solution. Taste matched placebo drink.	Blood samples were taken pre- and post exercise and 24h after. Plasma glucose, Interleukin-6 and plasma hepcidin were significantly higher in carbohydrate vs placebo post exercise but showed no difference after 24hours. No differences in plasma iron concentration, perceived exertion or heart rate.	The study supports the theory that exercise-induced up-regulation of hepcidin activity can cause iron deficiency in endurance athletes.
<b>Amino-acid</b> <b>Kraemer et al.</b> <sup>50</sup>	Randomised control trial. Level of evidence 1 Pedro 8/10	17 resistance trained men.	4 weeks of whole body resistance training with overreaching on consecutive days.	Amino-Acid group ingested 0.4 g kg <sup>-1</sup> essential and conditionally essential amino acids. Placebo group ingested an identical looking placebo.	1 repetition maximum squat and bench press decreased initially only in placebo group. Plasma creatine kinase concentration increased in placebo. No significant changes on blood pressure or hemotocrit. Haemoglobin significantly decreased in placebo group Amino-acid group showed enhanced recovery during overreaching but no benefit during normal training volume.	Amino-acid supplementation attenuates the initial muscle strength loss after overreaching with resistance training.



**Table 2-2 continued: Summary of studies for protein, carbohydrates and vitamins**

<b>Type of recovery modality</b>	<b>Study design and level of evidence</b>	<b>Participants and sample size</b>	<b>Exercise protocol</b>	<b>Intervention</b>	<b>Outcomes</b>	<b>Conclusion</b>
<b>Nutrition</b> <b>Mohseni et al.</b> <sup>7</sup>	Cross sectional, observation study. Level of evidence 4 Pedro 7/10	250 runners, volunteers.	Half and standard marathons.	n/a	Blood samples were taken pre- and post-race to measure hyponatremia, hypokalemia, renal dysfunction and hemoconcentration. 8.2 % of standard marathon runners were hyponatemic post-race. High rates of moderate renal dysfunction were observed post-race Full vs half marathon runners had significantly greater change in haemoglobin, which is a marker of dehydration.	Metabolic abnormalities are common in endurance racers but the clinical significance of it is unknown.
<b>Vitamin C</b> <b>Peters et al.</b> <sup>118</sup>	Double blind placebo controlled randomised controlled trial. 5/10 Level of evidence 2	92 Comrades marathon runners, volunteers.	Comrades marathon.	21 days of 600mg vitamin C supplement and placebo group took similar capsule containing citric acid.	Telephone interviews two weeks before and two weeks after the comrades. Significant fewer reports of upper respiratory tract infection in vitamin C group than in the placebo.	Vitamin C might have an prophylactic effect against increased upper respiratory tract infection symptoms after endurance exercise.
<b>Vitamin D</b> <b>Barker et al.</b> <sup>116</sup>	Randomised controlled trial. Level of evidence 1 Pedro	28 healthy and physical active males.	1 leg performed 10 sets of 10 repetitive eccentric and concentric jumps. 20 seconds rest between sets. Other leg was used as the control.	Group was spilt in 2 depending if they had vitamin D insufficiency or not.	Increase in Interleukin-19 and Interleukin-13 after exercise in group that had sufficient vitamin D. No difference between groups on muscle strength or function. Elevation in serum Interleukin-2 concentration in vitamin D insufficiency group. Elevation in pro-inflammatory cytokines in vitamin D insufficiency group.	Vitamin D sufficiency is associated with higher anti-inflammatory cytokines after muscle injury. Several pro-inflammatory cytokines are higher in vitamin D insufficient adults after injury.

### **2.6.3 Cryotherapy recovery modalities**

#### **a) Proposed physiological mechanisms to enhance recovery**

Cryotherapy is the cooling of a part of the body through various ways. Cryotherapy is proposed to aid in recovery from exercise-induced muscle damage and DOMS<sup>3</sup>. Cryotherapy cools the skin and the underlying tissues. It alters the blood flow by causing vasoconstriction, reducing the permeability to immune cells, thus reducing oedema and pain<sup>32</sup>. If combined with water immersion the hydrostatic pressure can displace fluids from the periphery to the central circulation causing a decrease in peripheral resistance and extracellular fluids<sup>5,32</sup>. Examples of cryotherapy such as cold water immersion, local application of ice packs and whole body cryotherapy are discussed below.

#### **2.6.3.1 Whole-body cryotherapy**

##### **a) Strategies for use**

The effect of ice or cryotherapy on the body has been well-researched. It is an effective way to decrease muscle damage and injuries. Cryotherapy results in peripheral vasoconstriction causing a decrease in circulation<sup>20</sup>. Whole body cryotherapy utilises a special chamber that is cooled down to sub-zero temperatures. The subject's body is exposed to extremely cold air between -110 °C and -140 °C for two to four minutes<sup>5</sup>.

##### **b) Current evidence**

Although only a few studies have been published, whole body cryotherapy showed a significant reduction in muscular enzymes, plasma creatine kinase concentrations and lactate dehydrogenase levels<sup>5,52,120</sup>. Hausswirth et al.<sup>5</sup> and Pournot et al.<sup>52</sup> conducted more recent studies on well-trained runners, comparing whole body cryotherapy with passive recovery. Both studies found no significant differences in plasma creatine kinase or lactate dehydrogenase concentrations between the two groups<sup>5,52</sup>. Pournot et al.<sup>52</sup> examined at the changes in inflammatory markers and found that the pro-inflammatory marker, delta interleukin-1 $\beta$ , was significantly decreased and the anti-inflammatory marker, delta interleukin-1ra, significantly increased one hour after whole body cryotherapy compared to passive recovery. There was no change in the number of leukocytes between groups. C-reactive protein levels increased less in the passive recovery group after 24 hours<sup>52</sup>. Hausswirth et al.<sup>5</sup> found a decreased perception of pain in isometric voluntary torque of the knee after one whole body cryotherapy session compared to the passive recovery group<sup>5</sup>. There is thus limited evidence for whole body cryotherapy as an effective recovery method.

### **2.6.3.2 Icepacks**

#### **a) Proposed physiological mechanisms to enhance recovery**

Cold and heat are legal methods to enhance performance during sport<sup>28</sup>. The use of locally applied ice decreases the skin and underlying tissues' temperature causing vasoconstriction of the blood vessels with reduced blood flow and a decreased metabolic rate for the area. This can reduce inflammation, oedema, pain<sup>28</sup>. Nemet et al.<sup>28</sup> found significant changes in systemic, hormonal and inflammatory markers with the application of local ice packs. The application of a local ice pack significantly decreased the pro-inflammatory mediator interleukin-1 $\beta$ , although the interleukin-6 levels remained the same. Interleukin-6 is a cytokine that is thought to play an important role in the inflammatory response after prolonged or intense exercise<sup>28</sup>. The ice pack application had a significant and even greater effect on decreasing the anti-inflammatory mediator interleukin-1ra<sup>28</sup>.

#### **b) Strategies for use**

Recent evidence suggests that ice may decrease muscle adaptation and therefore the training effect of the muscle post-training because of the effects on the inflammatory cytokines<sup>28</sup>. Some possible negative effects of ice application on athletic performance have been previously noted. The effect on DOMS is still unclear. It might be possible that ice should only be used after traumatic injuries, or in combination with other recovery modalities<sup>28</sup>.

#### **c) Current evidence**

Poppendieck et al.<sup>121</sup> conducted a systematic review of 21 randomised control trials and found that cooling the body or parts of it has a small effect on recovery of a trained athlete. The review showed that the recovery effect was most pronounced at about 96 hours post-exercise. The recovery effect was larger after endurance training than after strength training. Cold water immersion and whole body cryotherapy seemed to be more effective than ice packs<sup>121</sup>. The overall conclusion was that whole body cooling might be beneficial for competitive athletes, although the effects were small<sup>121</sup>. Tucker et al.<sup>122</sup> evaluated the effects of ice application on glycogen levels during recovery. There was a reduction in muscle glycogen re-synthesis with intermittent ice application after exhausting cycling<sup>122</sup>. In contrast, Torres et al.<sup>98</sup> performed a systematic review of ten randomised control trials of different type of cryotherapy interventions and meta-analyses of these trials were unreliable due to methodological heterogeneity and concluded that there is inconclusive evidence to support the use of cryotherapy as a recovery modality<sup>98</sup>.

Exercise is usually associated with an increase in anabolic hormones, which will decrease to pre-exercise levels during recovery. Nemet et al.<sup>28</sup> found that the application of local ice after exercise significantly decrease the anabolic hormones IGF-I and IGFBP-3 and increased the catabolic hormone IGFBP-1. The application of ice may therefore possibly reduce the anabolic effects of training and the pro-and anti-inflammatory cytokines after exercise and thereby assist in recovery<sup>28</sup>.

### **2.6.3.3 Cold water immersion**

#### **a) Proposed physiological mechanisms to enhance recovery**

Cool water immersion affects the blood flow and peripheral resistance of the body. The hydrostatic pressure of water immersion increases blood circulation, improving the removal of metabolites from the muscles and thereby assisting in recovery but without the extra metabolic cost compared to active recovery. The temperature of the water further assists blood circulation by causing peripheral vasoconstriction or vasodilatation<sup>9,20</sup>.

#### **b) Strategies for use**

The effect of the exposure to cold depends on the body's core temperature and the duration of the exposure of the cold. The body mass index and the level of obesity of a person may influence the impact the low temperature has on the skin and body core due to the insulating effect of adipose tissue<sup>52</sup> There are few scientific guidelines available on the optimal exposure time after different intensities and volumes of exercise<sup>20</sup>.

#### **c) Current evidence**

Cold water immersion is easy and affordable but can be time consuming<sup>91</sup>. A Cochrane Review by Bleakley et al.<sup>19</sup> examined 17 studies comparing cold water immersion to other modalities. They found that 75% of the studies used a water temperature between 10 °C to 15 °C. The remainder used water cooler than 9 °C. Treatment consists of mostly continuous water immersion up to waist- or sternum level for between 5 to 24 minutes in the 10 to 20 minutes directly post exercise<sup>19</sup>. They reviewed 14 studies comparing cold water immersion to contrast temperature water immersion, passive recovery, temperate water immersion, active recovery and full body compression garments. There were some significant differences between cold water immersion and passive recovery. At 24-, 48-, 72- and 96 hours respectively after the intervention, the cold water immersion group showed a significant decrease in pain on the visual analogue scale (VAS) compared to the passive recovery group. Two of the studies in the review found significant lower ratings of fatigue in the cold water immersion group<sup>19</sup>.

No significant effects in plasma creatine kinase concentrations, lactate dehydrogenase levels, myoglobin, C-reactive protein, interleukin-6, swelling, muscle power and strength were observed following cold water immersion. Only one study in the review reported a significant improvement in ankle range of motion following cold water immersion. This review found no significant evidence to conclude that cold water immersion is an effective recovery modality or that cold water immersion is more effective than any other recovery modality<sup>19</sup>. During subgroup analysis, it was clear that the effects of the cold water immersion were more effective after running than after resistance exercises in a laboratory. But most studies using running or cycling as an exercise had well-trained athletes as participants, where studies using resistance exercise used untrained participants<sup>19</sup>.

A well-designed study with a very small sample size of six participants found no significant differences in outcomes following cold water immersion or treatment with light emitting diode therapy, or even placebo light-emitting diode therapy<sup>91</sup>. Moore et al.<sup>110</sup> compared the use of cold water immersion, hot water immersion and passive recovery after a 90-minute shuttle test. They found no significant difference between the recovery modalities although there was a strong preference for the temperate water immersion by the athletes rather than the cold water immersion<sup>110</sup>. In 41 elite male team sport athletes doing 20 minutes of exhaustive exercises, there was a significant difference in plasma creatine kinase concentrations and lactate dehydrogenase levels after recovery with cold water immersion or contrast temperature water immersion compared to passive recovery or temperate water immersion. They found that there was less loss in muscle force after recovery with cold water immersion than after contrast temperature water immersion, temperate water immersion or passive recovery. Unfortunately this study was not well described and had multiple possible problems with bias<sup>21</sup>.

#### **2.6.3.4 Contrast temperature water immersion**

##### **a) Proposed physiological mechanisms to enhance recovery**

Contrast temperature water immersion is defined as immersion of part of the body in water at temperatures of more than 30 °C and less than 15 °C respectively<sup>32</sup>. A body part that is immersed in water undergoes the effects of hydrostatic pressure, resulting in vascular and muscular compression. The compression reduces early onset of inflammation and oedema. The alternating hot and cold temperature results in alternating vasodilatation and vasoconstriction, creating a pumping action that aids recovery by increasing blood flow and then assists in the removal of metabolic by-products<sup>21</sup>.

### **b) Strategies for use**

Bieuzen et al.<sup>32</sup> did a systematic review of 13 studies comparing contrast temperature water immersion to other modalities<sup>32</sup>, while Bleakley et al.<sup>19</sup> looked at five studies comparing contrast temperature water immersion to cold water immersion<sup>19</sup>. Unfortunately, the quality of the studies was low. Both reviews found the temperature of the hot water normally ranged between 35.5 °C and 45 °C, and the cold water between 8 °C and 15 °C. The outcomes suggested that the best results regarding pain relief were achieved when the hot water temperature was less than 40 °C. The duration of immersion and repetition of sessions varied greatly between the studies. The hot water immersion was applied for between one and three minutes, while all but one study utilised cold water for one minute only. The total time of immersion per session ranged from between 6 and 24 minutes, repeated between one and four times every 24 hours. Most studies ended with cold water immersion<sup>19,32</sup>. Support for this practice might be because cryotherapy activates the thermal nociceptors, reducing arterial flow and decreasing the circulation to those muscles.

This reduces the micro vascular flow surrounding the damaged tissue which leads to decreasing oedema and inflammation<sup>32</sup>. There is a lack of research for establishing the best dosage of contrast temperature water immersion<sup>19,32</sup>.

### **c) Current evidence**

The studies comparing contrast temperature water immersion and cold water immersion found very few significant changes in outcome measures. The cold water immersion showed a non-significant decrease in plasma creatine kinase and lactate dehydrogenase concentrations compared to the contrast temperature water immersion<sup>32</sup>. However, another study found that the plasma creatine kinase and lactate dehydrogenase concentrations changed significantly from exhaustive exercises if contrast temperature water immersion or cold water immersion are used for recovery<sup>21</sup>. Two studies reported significant differences in muscle strength in favour of cold water immersion from 48 hours onwards. There were no significant differences looking at the inflammatory markers or muscle power<sup>32</sup>.

Comparing the contrast temperature water immersion with the hot water immersion showed significant differences in pain for the initial 24 hours thus favouring contrast temperature water immersion. Maximal strength was significantly better in favour of contrast temperature water immersion from 24 to 96 hours after treatment. Muscle power showed a significant improvement after 72 hours in favour of temperate water immersion<sup>32</sup>. Bleakley et al.<sup>19</sup> found that there was no significant difference between the two recovery modalities. One study found a significant effect on pain reduction on the VAS at 24 and 48 hours in favour of cold water immersion. The biomarkers of plasma creatine kinase concentrations, lactate dehydrogenase levels and myoglobin, showed favourable outcomes for the cold water immersion groups but the results were not statistically significant<sup>19</sup>.

Comparing the contrast temperature water immersion with active recovery, stretching and compression garments showed no significant results<sup>32</sup>. There is thus some evidence to support the use of contrast temperature water immersion as a recovery modality and only guidelines for optimal dosages.

**Table 2-3: Summary of studies for whole body cryotherapy, ice treatments and heat treatments.**

<b>Type of recovery modality</b>	<b>Study design and level of evidence</b>	<b>Participants and sample size</b>	<b>Exercise protocol</b>	<b>Intervention</b>	<b>Outcomes</b>	<b>Conclusion</b>
<b>Whole body cryotherapy.</b> <b>Hauswirth et al.</b> <sup>5</sup>	Randomised cross over design. Level of evidence 2 Pedro 6/10	9 highly trained runners, volunteers.	Treadmill simulating endurance race once a week for three weeks.	Three different recovery modalities were applied at 1h, 24h & 48 h post exercise: Whole body cryotherapy for 3 minutes at -110 °C far-infrared Passive recovery	Plasma creatine kinase: no difference between groups. Isometric voluntary torque: whole body cryotherapy group recovered after 1 session, far-infrared group recovered later and passive recovery group showed no significant difference. Perceived perception of pain: reduced pain after 1 session whole body cryotherapy, far-infrared group showed reduction in pain later than in the whole body cryotherapy group.	Small study but concluded that whole body cryotherapy is more effective in restoring muscle strength and reducing pain than passive recovery or far-infrared.
<b>Whole body cryotherapy</b> <b>Herve Pournet et al.</b> <sup>52</sup>	Crossover design with a minimum of three weeks between trials. Level of evidence 2 Pedro 7/10	11 well-trained runners, volunteers.	Simulated trial run on treadmill.	Recovery modalities Whole body cryotherapy at -10 °C, -60 °C and -10 °C for 3 min. Or 30 min passive recovery.	Use blood samples for inflammatory markers. Delta interleukin-1 $\beta$ decreased 1h after whole body cryotherapy. Delta interleukin-1ra increased after 1h and 24h for whole body cryotherapy. No change in leukocytes.	Very small study but found that whole body cryotherapy applied immediately after exercise, can enhance muscle recovery by influencing the inflammatory process.
<b>Whole body cryotherapy</b> <b>Banfi et al.</b> <sup>120</sup>	Case series Level of evidence 4	10 male national rugby players randomly chosen from the team.	Regular training programme: 3 h every day.	Five days of whole body cryotherapy at -60 for 30 s and -110 for 2 min.	Used blood samples to evaluate effect of whole body cryotherapy on cardiac markers in well trained athletes. Creatine kinase decreased. NTproBNP increased.	No harmful effects of whole body cryotherapy on cardiac function.



**Table 2.3 continued: Summary of studies for whole body cryotherapy, ice treatments and heat treatments.**

<b>Type of recovery modality</b>	<b>Study design and level of evidence</b>	<b>Participants and sample size</b>	<b>Exercise protocol</b>	<b>Intervention</b>	<b>Outcomes</b>	<b>Conclusion</b>
<b>Passive recovery, hot water immersion, cold water immersion, contrast therapy</b> <b>Herve Pournet et al.</b> <sup>21</sup>	Randomised controlled trial. Level of evidence 2 Pedro 5/10	41 elite males, team sport, volunteers.	20 min intermittent exhaustive exercise consisting of 2 times 10 min exercises. Alternating 30 sec counter movement jumps with 30 sec of rowing at 80 % power and 30 sec rest.	15 min passive recovery. Hot water immersion at 36 °C. Cold water immersion at 10 °C. Contrast therapy: 90 sec in 10 °C and 90 sec in 42 °C. 5 cycles in total.	30s rowing, Max vertical jump, Max isometric voluntary knee extension, maximal counter-movement jump. Tested plasma levels of creatine kinase and LDH.	Cold water immersion showed less force loss than hot water immersion, contrast therapy and passive recovery.
<b>Cold water immersion, hot water immersion, passive recovery.</b> <b>Moore et al.</b> <sup>110</sup>	Randomised cross over design. Level of evidence 2 Pedro 5/10	11 Trained participants.	90 min Shuttle test. An intense test mimicking a sports game.	Different recovery modalities applied for 5 minutes. Cold water immersion at 0 °C. Hot water immersion at 20 °C. Passive recovery.	Knee extension peak torque decreased significantly after cold water immersion compared with hot water immersion and passive recovery. No significant effect of cold water immersion or hot water immersion on plasma creatine kinase levels, myoglobins, neutrophils, drop jump variables, single hop test, perceived recovery or perceived fatigue. Strong athlete preference for water immersion vs. passive recovery and hot water immersion over cold water immersion.	No significant difference between cold water immersion, hot water immersion and passive recovery. More research needed.

**Table 2.3 continued: Summary of studies for whole body cryotherapy, ice treatments, heat treatments, fatigue and recovery**

<b>Type of recovery modality</b>	<b>Study design and level of evidence</b>	<b>Participants and sample size</b>	<b>Exercise protocol</b>	<b>Intervention</b>	<b>Outcomes</b>	<b>Conclusion</b>
<b>Passive recovery, cold water immersion, contrast therapy</b> <b>Coffey et al.</b> <sup>92</sup>	Randomised multiple cross over design. Level of evidence 2 Pedro 4/10	14 highly active males, volunteers.	120% of a peak running speed run followed by a 15 min rest and 90% of peak running speed run. 4 hours later another 2 treadmill runs at 120% and 90% peak running speed.	Active recovery: 15 min run at 40% of peak running speed. Passive recovery: standing for 15 min. Cold water immersion: – 15 min at 10 °C. Contrast therapy: -60 sec at 10 °C and 120 sec at 42 °C for 15 min.	Heart rate, perceived exertion and blood lactate were recorded at rest, 4 min, 8 min, 12 min, 16 min and 20 min. Blood samples were taken.	Cold water immersion might be more effective than hot water immersion and passive recovery. But crossover design with only 72 h between tests, thus possible contamination of variables.
<b>Cold water immersion</b> <b>Leal Junior et al.</b> <sup>91</sup>	Cross-over randomised double blinded placebo controlled trial. Level of evidence 2 (Because small study sample) Pedro 8/10	6 young (17-25 yrs) well-trained male futsal athletes, volunteers.	Wingate test (short cycling sessions)	Three different recovery modalities applied. 5 min active light emitting diode therapy. 5 min placebo light emitting diode therapy. Cold water immersion in 50 litres at 5°C for 5 min.	Tested lactate levels, creatine kinase, C-reactive protein levels. Active light emitting diode therapy changed blood lactate levels and creatine kinase levels significantly. No significant difference between cold water immersion and placebo.	Very small sample size. No significant effect of cold water immersion over placebo light emitting diode therapy. More research needed.
<b>Ice pack with compression.</b> <b>Nemet et al.</b> <sup>28</sup>	Case series. Level of evidence 4	12 elite male handball players.	Treadmill sprint intervals.	Ice pack strapped on with a compression wrap. On for 15 min, off for 15 min and on for 15 more min.	Used blood samples for hormonal and inflammatory markers. Decreased pro-and anti-inflammatory cytokines. (Interleukin-1 $\beta$ and interleukin-1ra). Decreased anabolic hormones. Increased catabolic hormones.	Ice applied immediately after training is associated with greater decreased in pro-and anti-inflammatory cytokines and anabolic hormones.

## 2.7 SUMMARY OF THE LITERATURE

Endurance running is a popular sport, with increasing levels of participation globally. While there are numerous positive health benefits associated with endurance running, negative effects include exercise-induced muscle damage, DOMS, fatigue, overtraining and running-related injuries. This review has demonstrated the importance of recovery to optimise endurance running training and competition. There are numerous recovery modalities that may potentially accelerate or enhance the recovery process. However, this review has highlighted the lack of evidence for evidence-based guidelines for use of many recovery modalities. In addition, there is equivocal evidence for efficacy of many modalities.

Despite this lack of evidence, anecdotal reports suggest that the use of recovery modalities is commonplace. In addition, the use of recovery modalities is encouraged through advertising campaigns and marketing strategies. Interestingly, Myburgh et al.<sup>112</sup> posed the following question: *“Is today’s scientific research only focussed on the habits of elite athletes or are the elite athletes’ habits based on scientific evidence?”*<sup>112</sup>. Therefore, in an attempt to explore this question with specific reference to recovery modalities, the main purpose of the next chapter of this dissertation is to determine the use of recovery modalities by endurance runners.

### **3 CHAPTER THREE: THE USE OF RECOVERY MODALITIES BY ENDURANCE RUNNERS**

#### **3.1 INTRODUCTION**

Recovery is essential to facilitate the positive, adaptive effects of training, and to minimise negative training effects such as exercise-induced muscle damaged and fatigue<sup>3</sup>. An effective recovery strategy may enhance exercise performance and reduce the occurrence of training related musculoskeletal injuries. Recovery is essential a passive process; however there are numerous commercially available recovery modalities and recovery strategies that are purported to facilitate or accelerate the recovery process, with the goal of optimising exercise performance<sup>3,5,6,9,13,21,31</sup>. Although there are evidence-based guidelines for the use of some recovery modalities, such as protein or carbohydrate ingestion<sup>4,14,33,50</sup> and anti-inflammatory medication<sup>23,100,101,103</sup>, there is equivocal and often conflicting evidence for the efficacy of the majority of recovery modalities and strategies<sup>20,28,29,32</sup>. Some studies have shown that recovery modalities may not enhance the recovery process and that certain modalities may have little or no effect on exercise performance<sup>19,91,123</sup>.

However, anecdotal reports suggest that the use of recovery modalities is common practice, despite the lack of evidence for efficacy of many modalities. The prevalence and pattern of use of recovery modalities in endurance runners has not been established. This information is important to promote safe, best practice guidelines and to determine the need for educational interventions. Accordingly, the aim of this study was to determine the prevalence and the pattern of use of recovery modalities by endurance runners. The specific objectives of this dissertation have been described in Section 1.2 on page 2.

## **3.2 METHODS**

### **3.2.1 Study design**

This study had a descriptive correlation design.

### **3.2.2 Participants**

#### **3.2.2.1 Inclusion criteria**

Healthy male and female endurance runners who were 18 years or older were recruited for the study.

Runners who had been training for at least six months in the 12-months preceding the study, and who were training a minimum of 30 km.wk<sup>-1</sup> were included in this study. Participants were required to be English literate, as the questionnaire was only available in English\*.

#### **3.2.2.2 Exclusion criteria**

Participants who failed to provide informed consent as well as participants who did not complete the mandatory sections of the questionnaire were excluded from the study.

#### **3.2.2.3 Recruitment of participants**

Participants were recruited through South African running clubs and at races. Initially an electronic search for running clubs in South Africa was conducted. A total of 352 running clubs were identified and contacted via email (Appendix A: Invitation to running clubs). Unfortunately 178 email addresses were invalid and email delivery of the study invitation letter failed. The principal researcher also contacted the 50 largest running clubs in South Africa telephonically. The chairman or secretary of each running club was requested to distribute the participant information sheet to members of the running club (Appendix B: Participant information sheet). The participant information sheet contained an outline of the study, an invitation to club members to participate in the study and a link to the electronic version of the questionnaire on FluidSurvey®.

The race calendar for South Africa was scrutinised to identify trail runs, half-, full and ultramarathons that were taking place during the nine-week data collection period for this study. Permission was obtained from individual race organisers to approach runners at the end of the race, regarding participation in the study.

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\*The decision to only have an English version of the questionnaire was based on the findings of two recent MPhil (Sports Physiotherapy) research studies (unpublished data) that also conducted surveys among South African runners and cyclists. In both studies, participants (n≈700) only accessed the English version of the survey, despite the survey also being available in Afrikaans and isiXhosa. The University of Cape Town, Faculty of Health Science Human Research Ethics Committee was consulted and approved this study protocol with the questionnaire only being available in English.

Permission was granted from six race organisers and all of these events were attended to maximise potential recruitment of participants for this study. At each race the principal researcher and a research assistant approached as many runners as possible once they had completed the race. Runners were asked if they were interested in participating in a survey about the use of different recovery modalities. If they expressed interest the requirements of the study were briefly explained. Runners were given the option to provide written informed consent and complete a hard copy questionnaire at the race; or they were invited to complete the electronic questionnaire on FluidSurvey®. Participants who completed the hard copy questionnaire were asked not to access the online survey. Only five participants completed the hard copy questionnaire. Participants electing to complete the online version gave the principle researcher an email address. Seven hundred and twenty-four email addresses were collected at the six events. An email containing the participant information letter (Appendix B: Participant information sheet), with an outline of the study and a link to the survey was sent to these email addresses after each race.

#### **3.2.2.4 Sample size determination**

In the absence of more definitive data regarding the use of recovery modalities in endurance runners, the prevalence of supplement use in athletes was used to calculate the required sample size for this study. An expected frequency of 60% was selected based on previous studies which reported the prevalence of supplement use of 45% to 85%<sup>15,124</sup>. If the worst expected frequency was 55%, with confidence intervals of 80%, 90% and 95%, the required sample size would be 140, 211 and 276 participants respectively. It is recognised that response rates for questionnaire-based studies are often low, and that may range from 25% to 56%<sup>125,126</sup>. Therefore, based on an estimated response rate of 50%, we aimed to recruit 500 volunteers to ensure sufficient statistical power in case some participants failed to complete the survey.

#### **3.2.3 Measurement instrumentation**

A questionnaire (Appendix E: Questionnaire) was compiled by the principal researcher to obtain information regarding the use of recovery modalities by endurance athletes. In the online version, participants were required to read an information sheet and provide informed consent. Participants were then required to complete four screening questions to ensure they met the inclusion criteria for the study. If participants did not meet the inclusion criteria, they could not continue the survey and were directed to a page thanking them for their interest in the study. Participants who met the inclusion criteria were able to access the questionnaire. The questionnaire consisted of four sections. Section A included the participant's demographic information. Section B briefly assessed relevant medical history. Section C contained questions regarding training habits and competition history. Section D consisted of questions on frequently used recovery modalities. Participants were requested to indicate all the various recovery modalities they used during the twelve months preceding the study.

Each of these different recovery modalities were followed by seven to fourteen questions to gain more information about the frequency of use, dose intervals, and the perceived effectiveness thereof. The participants had to indicate at the pattern of use questions how frequently they used a specific recovery modality under specific circumstances by choosing “always”, “sometimes”, “rarely”, “never” or “not applicable” options. Participants were asked to identify the proposed mechanism of action of the different recovery modalities they utilised. The evidence-based mechanism of action of the recovery modalities are shown in Table 3-1 (page 47).

The questionnaire was available in both hard copy and electronic format. FluidSurvey®, a Canadian-developed electronic survey tool, was used to collect the data electronically. Participants were given a web link: <http://fluidsurveys.com/s/endurancerunnerst> to access the electronic questionnaire. FluidSurvey® allowed easy online access and enabled participants to answer sections applicable to them only, while hiding non-relevant questions. Participants were able to anonymously complete and submit the survey online. The hardcopy was a printout of the same questionnaire, but participants were required to manually skip non-relevant questions. Clear instructions guided them to the next relevant question.

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<sup>†</sup> Please note that this web link is no longer active on the internet, as data collection has ended on 12 June 2014.

**Table 3-1: Evidence-based mechanisms of action of different recovery modalities.**

<b>Recovery modality</b>	<b>Most appropriate answer/s</b>	<b>Physiology</b>
<b>Passive recovery</b>	Changes the flow of blood	Reduction in heart rate and metabolism slows the blood flow <sup>3,94</sup> .
<b>Active recovery</b>	Speeds up energy restoration	An increased blood flow to the heart and muscles increase cell metabolism, lactate metabolism and the replenishing of glycogen stores <sup>3,22,94</sup> .
	Reduces lactic acid build up	
	Changes the flow of blood	
<b>Protein</b>	Speeds up energy restoration	Protein or amino acid supplementation reduces the initial muscle strength loss and increase the muscle protein synthesis <sup>14,50,115</sup> .
	Strengthens the body	
<b>Cryotherapy</b>	Reduces pain and swelling	Cryotherapy causes vasoconstriction that changes the permeability to immune cells and thus reducing oedema and pain <sup>5,13,32</sup> .
	Changes the flow of blood	
<b>Anti-inflammatory medication</b>	Reduces swelling	Anti-inflammatory medication blocks the cyclo-oxygenase and inhibits pro-inflammatory prostaglandins synthesis thereby reducing oedema and pain <sup>100,102,103,119</sup> .
	Reduces pain	
<b>Massage</b>	Reduces pain	Lowering stress levels and creating a feeling of well-being <sup>80</sup> .
<b>Vitamins and minerals</b>	Speeds up energy restoration	Vitamin A, B and E has a role in energy metabolism, while Vitamin D may have an influence on the regulation of anti-inflammatory cytokine production. Vitamin C deficiency can increase fatigue and reduce energy <sup>115,116</sup> .
	Strengthens the body	
<b>Compression</b>	Reduces swelling	Compression garments to increase the blood circulation by assisting the muscle pump action mechanism. It improves the removal of metabolites, increases tissue oxygenation and decreases edema <sup>20,23</sup> .
	Changes the flow of blood	
<b>Carbohydrates</b>	Speeds up energy restoration	Improves glycogen synthesis <sup>3,80</sup> .
<b>Heat</b>	Changes the flow of blood	Heat causes peripheral vasodilatation, increasing the blood flow to the region, enhancing the removal of metabolic by-products and reduces pain via the pain gate theory <sup>3,28</sup> .
	Reduces pain	
<b>Contrast therapy</b>	Reduces swelling	Alternating heat and cold results in alternating vasodilatation and vasoconstriction creating a pumping action that increases blood flow and assists in the removal of metabolic by-products <sup>28</sup> .
	Changes the flow of blood	

Please note that stretching had no correct answer option in the questionnaire and was excluded during final analyses.



### **3.2.3.1 *Validity of the questionnaire***

A panel of two sports physiotherapists and one biokineticist with expertise in exercise science were asked to validate the questionnaire. The panel of experts was selected according to their expertise, reputation and interest in exercise science and endurance sport. The validators were given a three-week period to critically review and comment on clarity, significance and consistency of survey questions to ensure validity of content. Two validators returned the questionnaire with feedback. The third validator was reminded three times to provide feedback but without success. The principal researcher and supervisors assessed the feedback and incorporated it into the questionnaire. The feedback consisted mainly of simplifying certain questions and adding a few more options for answers to some questions. There was no conflicting feedback from the two validators. After adapting the questionnaire, it was returned to the validators to confirm their consensus and approval. Both validators agreed that the questionnaire covered all aspects of the study's objectives.

### **3.2.3.2 *Feasibility of questionnaire***

A pilot study utilising the questionnaire was conducted at a local running club. Five endurance runners were asked to complete the questionnaire. Their answers were reviewed to ensure that valid answers were given to the survey questions and to optimise the data collection process. The participants were asked to comment on the ease of completion and comprehension of the questionnaire. Most of the comments related to wording of certain questions. Amendments to improve clarity of questions were made as deemed necessary by the principal researcher. The revised questionnaire was then piloted on two endurance runners. No additional feedback was received and the second version of the questionnaire was accepted. The data from the pilot studies did not form part of the final results of the study.

### **3.2.4 *Procedure***

This protocol was submitted for ethical approval to the University of Cape Town, Faculty of Health Science Human Research Ethics Committee. After ethical approval had been obtained the questionnaire was validated and piloted as described in Sections 3.2.3.1 and 3.2.3.2. A FluidSurvey© account was opened ([www.fluidsurveys.com](http://www.fluidsurveys.com)) and the questionnaire was uploaded to the website. The survey's hyperlink and online questionnaire were then tested by the principal researcher to ensure that it was in working order. Data collection was then commenced as described in Section 3.2.2.3. The electronic version of the questionnaire was available on the FluidSurvey© website for nine weeks and six events were attended during this period. All participants were thanked immediately on completion of the questionnaire and were provided with a link to an information leaflet on recovery modalities (Appendix F: Information leaflet).

This information leaflet contained the latest evidence based information regarding the benefits and use of different recovery modalities. After all questionnaires had been collected, data analysis and write up were commenced.

### **3.2.5 Statistical analyses**

Statistical analyses were performed using the Statistica software (StatSoft, Inc. 2012, STATISTICA Data analysis software system, version 12. [www.statsoft.com](http://www.statsoft.com)) and IBM SPSS Statistics (version 21, 2012). Pearson's chi-square measures of association and percentages were used for categorical data, for example, gender, level of education, monthly income, current injuries, type of training and satisfaction with level of fitness. Independent t-tests were used for all numerical data. Numerical data presented as the mean and standard deviations ( $X \pm SD$ ) were age, weight, stature and body mass index (BMI). The pattern of the use of different recovery modalities are presented as the number of responses (n) and percentages (%). Forward stepwise analyses were performed to predict the probability of participants using a specific recovery modality. Two different predictor models, a demographic and a training model, with independent variables were used. The predictor variables were coded and are listed in Table 3-2. Regression analyses were performed on all recovery modalities. All variables in one model were entered simultaneously, CIs were 95% and statistical significance was accepted as  $p < 0.05$ . All of the forward stepwise regression tables show the odds ratio (Exp (B)), p-values, 95% CIs and the Wald test for each of the predictors. The Wald test is used to assess the significance of the variable based on the sample estimate<sup>125</sup>.

**Table 3-2: Predictor variables coded for forward stepwise regression analyses.**

Model	Predictor variable	Coded 1	Coded 0
<b>Demographic</b>	Age	≥ 40	≤ 39
	Gender	Male	Female
	Body mass index (BMI)	18.5 to 24.9	≤ 18.4 and ≥25
	Highest level of education	University or college	All other categories
	Monthly income	> R21 000	≤ R21 000
<b>Training</b>	Training distance	≥ 40 km per week	≤ 39.9 km per week
	Running experience	Running ≥ 6 years	Running ≤ 5 years
	Marathon frequency	≥ 4 standard marathons	≤ 3 standard marathons
	Running preference	≥ 50% Road running	≤ 50% road running
	Current injuries	Yes	No

### **3.2.6 Ethical considerations**

The study adhered to the principles outlined in the Declaration of Helsinki (Fortaleza, Brazil, 2013). Ethical approval was obtained from the University of Cape Town, Faculty of Health Sciences Human Research Ethics Committee (HREC REF: 379/2013) (Appendix I: Ethics).

The first page of both the electronic and hard copy questionnaire contained informed consent forms (Appendix C: Informed consent form - Electronic version and Appendix D: Informed consent form - Hard copy version) describing the study in non-scientific language to explain the background, aim of the study and what was required by a participant. Participants had to tick an appropriate box to consent to participate in the study before they could access the questionnaire. While completing the questionnaire the participants could withdraw from the study at any stage. As online responses were anonymous it was impossible to withdraw from the study after the questionnaire had been completed. The completed hard copies were kept confidential and were stored in a locked safe. All other data were securely stored on a password-protected laptop and only the principal researcher and supervisors had access to the data.

#### **3.2.6.1 Risk to participants**

There was no risk to participants in this study as no physical tests were performed. All information from the study was kept anonymous and confidential.

### **3.2.6.2 *Benefits to participants***

Participants were provided with an information leaflet (Appendix F: Information leaflet) that contained the latest evidence-based information regarding the benefits and use of different recovery modalities and relevant links to more information, on completion of the questionnaire. This information may assist participants to plan individual recovery schedules. Unfortunately, as no personal details were captured and responses were anonymous or confidential, it was not possible to provide participants with feedback from the results of this study.

## **3.3 RESULTS**

### **3.3.1 Participants**

The questionnaire was available online at FluidSurvey© from 8 April 2014 to 12 June 2014. During the nine weeks that the survey was active a total of 649 responses were received. Only five responses were from participants who completed the hardcopy survey. The other 644 respondents accessed the online survey. Out of the total electronic surveys returned 26 responses were excluded due to not meeting the inclusion criteria. A further 190 responses were excluded as participants failed to complete all the mandatory sections of the questionnaire. Overall, 420 respondents that fully completed the survey and 13 responses that partially completed the survey were included in the study. Therefore data from 433 respondents were included for analysis (Figure 3-1).

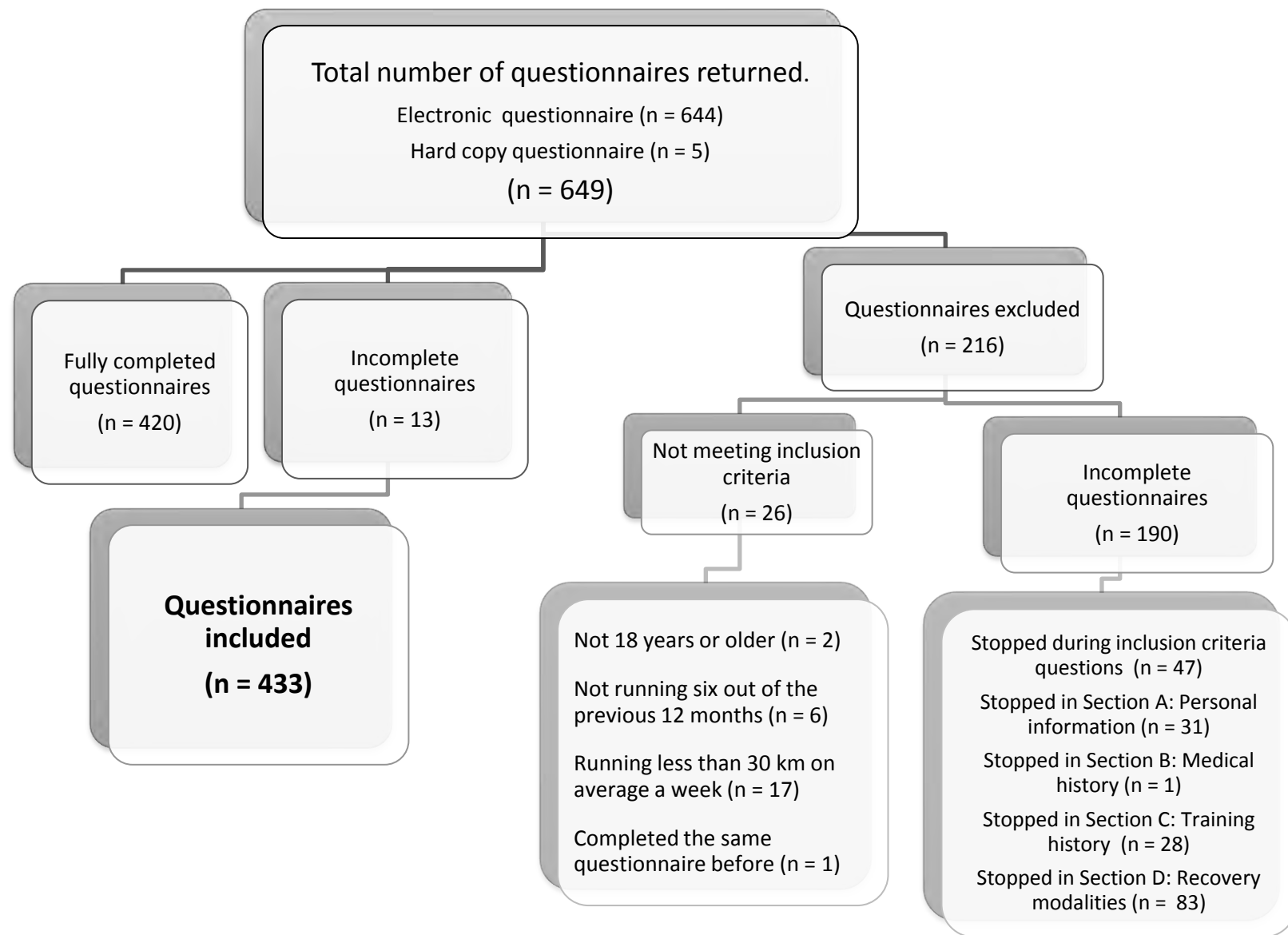


Figure 3-1: Summary of study participants.

### 3.3.2 Descriptive characteristics

The participants included in the study consisted of 154 (36%) females and 279 (64%) males. The mean age of the participants was  $40.1 \pm 9.7$  years (range 20 to 71 years) (Table 3-3). The participants were well-educated with 326 (75%) having University or College education. A high number of participants (68%) earned more than R21 000 a month. The descriptive characteristics of participants are shown in Table 3-3 and Table 3-4. There were no significant differences between males and females in age, highest level of education, current injuries, chronic medical conditions or years of running. As expected there were significant differences between male and female participants in body mass ( $t = 17.6$ ;  $p = 0.000001$ ), stature ( $t = 19.6$ ;  $p = 0.000001$ ), and body mass index (BMI) ( $t = 8.2$ ;  $p = 0.000001$ ). There was also a significant difference between the monthly income of male and female participants ( $\chi^2 = 67.8$ ;  $p = 0.000001$ ).

**Table 3-3: Descriptive characteristics of participants (n=433). Data are expressed as mean  $\pm$  standard deviation (SD).**

Variable	Female (n = 154)	Male (n = 279)	Total (n = 433)	t	P
Age (years)	39.6 $\pm$ 9.8	40.4 $\pm$ 9.7	40.1 $\pm$ 9.7	0.8	0.43
Stature (m)	1.71 $\pm$ 0.11	1.83 $\pm$ 0.11	1.72 $\pm$ 0.11	19.6	0.000001**
Body mass (kg)	59.6 $\pm$ 8.1	78.2 $\pm$ 11.7	71.6 $\pm$ 13.8	17.6	0.000001**
BMI (kg.m <sup>-2</sup> )	21.8 $\pm$ 2.7	24.4 $\pm$ 3.3	23.5 $\pm$ 3.34	8.2	0.000001**

\*\*  $p = < 0.01$

**Table 3-4: Socio-demographic characteristics and medical and injury history of participants (n=433). Data are expressed as number of responses (n) and column percentages (%).**

Highest level of education (Categories are from the South African Census 2011)					
Variable	Female (n = 154)	Male (n = 279)	Total (n = 433)	$\chi^2$	p
University	112 (73%)	198 (71%)	310 (72%)	2.70	0.75
High/Secondary School	1 (0.23%)	3 (0.69%)	4 (1%)		
College	18 (12%)	30 (11%)	48 (11%)		
Standard 10/Grade 12	12 (8%)	33 (13%)	44 (10%)		
Other	11 (7%)	15 (5%)	26 (6 %)		
Monthly income					
More than R 30000	38 (25%)	168 (60%)	206 (48%)	67.81	0.000001*
R 25001 to R 30000	15 (10%)	32 (12%)	47 (11%)		
R 21001 to R 25000	21 (14%)	22 (8%)	43 (10%)		
R 17501 to R 21000	19 (12%)	17 (6%)	36 (8%)		
R 12501 to R 17500	26 (17%)	14 (5%)	40 (9%)		
R 8001 to R 12500	13 (8%)	14 (5%)	27 (6%)		
R 4001 to R 8000	9 (6%)	8 (3%)	17 (4%)		
R 1751 to R 4000	2 (1%)	2 (1%)	4 (1%)		
Less than R 1750	11 (7%)	2 (1%)	13 (3%)		
Current injuries					
No	133 (86%)	244 (88%)	377 (87%)	0.10	0.75
Yes	21 (14%)	35 (13%)	56 (13%)		
Chronic medical conditions					
No	136 (88%)	238 (85%)	374 (86%)	0.76	0.38
Yes	18 (12%)	41 (15%)	59 (14%)		

\*\* p = < 0.01

Please note that due to rounding of figures, all percentages do not add up to 100%

### 3.3.3 Training history

Just over half of the participants (n = 226; 52%) had been running for five years or less. There were significant differences between male and female participants in the number of standard marathons (p = 0.04; t = 2.8). Male participants were also significantly faster over half marathons (p = 0.000001; t = 6.9) and standard marathons distances (p = 0.000001; t = 3.8) compared to female participants (Table 3-5). There were no significant differences between males and females for any other training or racing variables (Table 3-5).

**Table 3-5: Training and racing history. Data are presented as mean ± standard deviation (SD).**

Weekly training history					
Variable	Female (n = 154)	Male (n = 279)	Total (n = 433)	t	p
Average weekly training distance (km)	54.1 ± 30.4	60.0 ± 50.3	57.9 ± 44.3	1.3	0.18
Weekly training frequency (n)	4.6 ± 1.1	4.5 ± 1.4	4.5 ± 1.3	-0.1	0.93
Racing history					
Number of half marathons completed (n)	6 ± 6	6 ± 6	6 ± 6	0.3	0.78
Average half marathon pace (m.s <sup>-1</sup> )	3.0 ± 0.4	3.3 ± 0.5	3.2 ± 0.5	6.9	0.0001**
Number of standard marathons completed	1 ± 3	2 ± 3	2 ± 2	2.0	0.04*
Average standard marathon pace (m.s <sup>-1</sup> )	2.7 ± 0.4	3.1 ± 0.8	3.0 ± 0.7	3.8	0.0001**
Number of ultramarathons completed	1 ± 1	1 ± 1	1 ± 1	2.8	0.01*
Average ultramarathon distance	60.7 ± 16.8	62.9 ± 18.4	62.2 ± 17.9	0.9	0.39
Average ultramarathon pace (m.s <sup>-1</sup> )	2.6 ± 0.4	2.7 ± 0.7	2.7 ± 0.6	1.4	0.14

\* p < 0.05; \*\* p < 0.01

The components of participants' running programmes are shown in Table 3-6. Cross-training (n = 207; 48%) and strength training (n = 226; 52%) were the least popular components of running training programmes. In addition, almost half of the participants (n = 210; 49%) indicated that road running was their preferred discipline (defined as 80% or more of total training time) (Table 3-7). Additional training characteristics are reported in Table 12-1 and Table 12-2 in Appendix G: Additional analyses.



**Table 3-6: Components of participant' (n = 433) running training programme. Data are expressed as number of responses (n) and column percentages (%).**

Training includes					
Variable	Female (n = 154)	Male (n = 279)	Total (n = 433)	$\chi^2$	p
Speed training	112 (73%)	201 (72%)	313 (72%)	0.023	0.88
Hill training	144 (94%)	255 (91%)	399 (92%)	0.61	0.43
Cross training	79 (51%)	128 (46%)	207 (48%)	1.17	0.28
Stretching	106 (69%)	191 (69%)	297 (69%)	0.01	0.94
Strength training	84 (55%)	142 (51%)	226 (52%)	0.53	0.47

**Table 3-7: Preferred running disciplines of participants (n = 433) expressed as a percentage of total training time. Data are presented as number of responses (n) and column percentages (%).**

Preferred type of running					
Percentage of training	Track running	Road running	Trail running	Cross country running	Treadmill running
0%	304 (70%)	4 (1%)	128 (30%)	351 (81%)	303 (70%)
Less than 10 %	82 (19%)	8 (2%)	93 (22%)	50 (12%)	76 (18%)
10 to 20 %	37 (9%)	13 (3%)	73 (17%)	19 (4%)	35 (8%)
21 to 30 %	5 (1%)	11 (3%)	42 (10%)	4 (1%)	7 (2%)
31 to 40 %	2 (1%)	24 (6%)	26 (6%)	3 (1%)	5 (1%)
41 to 50 %	3 (1%)	28 (6%)	21 (5%)	2 (0.5%)	4 (1%)
51 to 60 %	0 (0%)	25 (6%)	16 (4%)	1 (0.3%)	0 (0%)
61 to 70 %	0 (0%)	39 (9%)	11 (3%)	0 (0%)	0 (0%)
71 to 80 %	0 (0%)	71 (16%)	5 (1%)	1 (0.3%)	1 (0.3%)
81 to 90 %	0 (0%)	83 (19%)	9 (2%)	1 (0.3%)	0 (0%)
91 to 100 %	0 (0%)	127 (29%)	9 (2%)	1 (0.3%)	3 (1%)

### **3.3.4 Recovery modalities**

For the results and discussion section of this dissertation, the recovery modalities will be listed from the most commonly to the least commonly utilised modalities. Participant's self-reported use of recovery modalities is shown in Table 3-8. Passive recovery was the used most commonly used modality (n = 388; 90%), followed by active recovery (n = 327; 76%) and stretching (n = 299; 67%). Male participants reported significantly higher use of carbohydrates as a recovery modality, compared to female participants ( $\chi^2 = 3.4$ ; p = 0.07). There were no significant differences between male and female participants in self-reported use of other recovery modalities. Participants used an average of  $6 \pm 2$  different recovery modalities, with the majority of participants reportedly using between four and nine different modalities (Table 3-9). A list of recovery modalities reported as "other" in the questionnaire is shown in Table 12-3 in Appendix G: Additional analyses. These "other" recovery modalities were not included in the main dissertation results, as each modality was used by less than 1% of participants in this study.

Table 3-8: Self-reported use of recovery modalities by participants (n = 433). Data are presented as number of responses (n) and percentages (%) of the total group, and numeric data are presented as mean  $\pm$  standard deviation (SD).

Recovery modalities	Female (n = 154)	Male (n = 279)	Total (n = 433)	$\chi^2$	p
Passive recovery	136 (88%)	252 (91%)	388 (90%)	0.59	0.44
Active recovery	115 (76%)	212 (77%)	327 (76%)	0.42	0.84
Stretching	109 (71%)	190 (68%)	299 (67%)	0.33	0.33
Protein	90 (58%)	171 (62%)	261 (60%)	0.39	0.53
Cryotherapy	69 (47%)	140 (52%)	209 (48%)	0.85	0.36
Anti-inflammatory medication	76 (50%)	124 (45%)	200 (46%)	0.95	0.33
Massages	76 (49%)	123 (44%)	199 (46%)	1.47	0.23
Vitamins and minerals	72 (47%)	124 (45%)	196 (45%)	0.21	0.65
Compression	61 (40%)	114 (41%)	175 (40%)	0.04	0.84
Carbohydrates	49 (32%)	113 (41%)	162 (37%)	3.40	0.007**
Heat	47 (31%)	75 (27%)	122 (28%)	0.71	0.40
Contrast therapy	27 (18%)	64 (23%)	91 (21%)	1.68	0.20
Other modalities	13 (8%)	23 (8%)	36 (8%)	0.001	0.99
	<b>Female mean <math>\pm</math> SD</b>	<b>Male mean <math>\pm</math> SD</b>	<b>Total mean <math>\pm</math> SD</b>	<b>t</b>	<b>p</b>
Number of recovery modalities used by participants	6 $\pm$ 2	6 $\pm$ 2	6 $\pm$ 2	0.32	0.75

\*\* p < 0.01

**Table 3-9: Number of different recovery modalities used by participants (n = 433). Data are presented as number (n) and percentages (%) of responses.**

<b>Number of recovery modalities used</b>	<b>Number of participants</b>
<b>One</b>	5 (1%)
<b>Two</b>	19 (4 %)
<b>Three</b>	38 (9%)
<b>Four</b>	57 (13%)
<b>Five</b>	54 (13%)
<b>Six</b>	75 (17%)
<b>Seven</b>	70 (16%)
<b>Eight</b>	53 (12%)
<b>Nine</b>	35 (8%)
<b>Ten</b>	12 (3%)
<b>Eleven</b>	10 (2%)
<b>Twelve</b>	5 (1%)

#### **3.3.4.1 Pattern of use**

The next section describes the pattern of use of each recovery modality. It includes the frequency of use, as well as the type of the recovery modality used and the method of application. For some recovery modalities such as stretching, protein, anti-inflammatory medication, compression and carbohydrates, participants were asked if they used the specific recovery modality during training and races respectively. During the analyses process of each recovery modality, the total number of participants that reported the use of that recovery modality during training or races was used.

##### **a) Passive recovery**

Passive recovery was commonly used in almost all circumstances by 388 participants. Table 3-10 shows the pattern of use of passive recovery. A total of 356 participants, (92%) reported that they used passive recovery when they are injured and 346 participants (89%) used passive recovery when they are very tired. A further 159 participants (41%) stated that they always used passive recovery after ultramarathons and 138 participants (36%) always used it after standard marathons. Participants rested for an average of  $1 \pm 1$  day in an average training week,  $3 \pm 3$  days after a standard marathon and  $5 \pm 4$  days after an ultramarathon (Table 3-11).

**Table 3-10: Pattern of use of passive recovery: Data are presented as numbers (n) and percentages (%) of the total number of participants using passive recovery (n = 388).**

Pattern of use of passive recovery (n = 388)					
Variable	Always	Often	Sometimes	Rarely	Total
For an ultramarathon	159 (41%)	65 (17%)	23 (6%)	5 (1%)	252 (65%)
For a standard marathon	138 (36%)	80 (20%)	45 (12%)	12 (3%)	275 (71%)
For a half marathon	57 (15%)	64 (16%)	105 (27%)	81 (21%)	307 (79%)
Weekly, during normal training	86 (22%)	76 (20%)	96 (25%)	73 (19%)	331 (85%)
When injured	219 (56%)	95 (25%)	34 (9%)	8 (2%)	356 (92%)
Only when in pain	149 (38%)	117 (30%)	73 (19%)	18 (5%)	357 (92%)
Only when very tired	85 (22%)	105 (27%)	116 (29%)	40 (10%)	346 (89%)
When training and racing hard	78 (20%)	107 (30%)	109 (28%)	42 (11%)	336 (87%)
Depends on the day/ no regular pattern	32 (8%)	49 (13%)	73 (19%)	43 (11%)	197 (87%)

**Table 3-11: Frequency of use of passive recovery (n = 388). Data are presented as mean and standard deviation (SD) of the number of participants that utilised passive recovery for the specific scenario.**

Passive recovery (n = 388)	
Variable	Mean $\pm$ SD
Number of rest days during a normal training week (n = 376)	1 $\pm$ 1
Number of rest days after a half marathon (n = 366)	1 $\pm$ 1
Number of rest days after a standard marathon (n = 306)	3 $\pm$ 3
Number of rest days after an ultramarathon (n = 271)	5 $\pm$ 4

#### **b) Active recovery**

The pattern of use of active recovery is shown in Table 3-12. Active recovery was used by 327 participants, predominantly for recovery after training and races. Active recovery was used by between 62% and 85% of participants after a race. Only 38 participants (12%) reported that they always use active recovery when they are training hard, although 97 (29%) and 76 (24%) of participants often use active recovery when they are training hard or when they are tired. Running and walking were the most popular types of active recovery. Active recovery sessions' durations are shown in Table 3-13. Participants exercised on average once a day for 2 days to recover after a race. The most common active recovery session duration was 26 to 30 minutes (n = 86; 26%), followed by 56 to 60 minutes (n = 54; 17%).

**Table 3-12: Pattern of use of active recovery and methods of active recovery. Data are presented as numbers (n) and percentages (%) of the total number of participants using active recovery (n = 327).**

<b>Pattern of use of active recovery (n = 327)</b>					
<b>Variable</b>	<b>Always</b>	<b>Often</b>	<b>Sometimes</b>	<b>Rarely</b>	<b>Total</b>
<b>For an ultramarathon</b>	70 (22%)	64 (19%)	53 (16%)	15 (4%)	202 (62%)
<b>For a standard marathon</b>	71 (22%)	83 (28%)	62 (19%)	14 (4%)	230 (70%)
<b>For a half marathon</b>	66 (20%)	96 (29%)	77 (24%)	38 (12%)	277 (85%)
<b>Weekly, during normal training</b>	66 (20%)	97 (29%)	68 (20%)	41 (12%)	272 (83%)
<b>When injured</b>	50 (16%)	61 (19%)	78 (24%)	43 (13%)	232 (71%)
<b>Only when in pain</b>	41 (12%)	58 (18%)	84 (28%)	48 (15%)	231 (71%)
<b>Only when very tired</b>	30 (9%)	76 (24%)	96 (29%)	51 (16%)	253 (77%)
<b>When training and racing hard</b>	38 (12%)	97 (29%)	102 (31%)	33 (10%)	270 (83%)
<b>Depends on the day/ no regular pattern</b>	24 (8%)	39 (12%)	44 (13%)	38 (12%)	145 (44%)
<b>Type of exercise</b>					
<b>Running</b>	59 (18%)	129 (39%)	94 (24%)	25 (8%)	307 (94%)
<b>Walking</b>	22 (7%)	91 (28%)	79 (24%)	51 (16%)	243 (74%)
<b>Cycling</b>	10 (3%)	59 (18%)	79 (24%)	37 (11%)	185 (57%)
<b>Swimming</b>	7 (2%)	49 (15%)	48 (15%)	51 (16%)	155 (47%)
<b>Gym</b>	18 (6%)	67 (20%)	50 (16%)	40 (12%)	175 (54%)

**Table 3-13: Active recovery session duration. Data are expressed as numbers (n) and percentages (%) of the total number of participants using active recovery.**

<b>Variable</b>	<b>Number of participants (n = 327)</b>
<b>1 to 10 minutes</b>	12 (4%)
<b>11 to 15 minutes</b>	5 (2%)
<b>16 to 20 minutes</b>	28 (9%)
<b>21 to 25 minutes</b>	16 (5%)
<b>26 to 30 minutes</b>	86 (26%)
<b>31 to 35 minutes</b>	30 (9%)
<b>36 to 40 minutes</b>	26 (8%)
<b>41 to 45 minutes</b>	29 (9%)
<b>46 to 55 minutes</b>	17 (6%)
<b>56 to 60 minutes</b>	54 (17%)
<b>More than 60 minutes</b>	22 (7%)

### **c) Stretching**

The pattern of use of stretching is shown in Table 3-14. Stretching was widely used by 299 participants, with 162 participants (80%) and 195 participants (95%) stretching before and after training respectively; and 80 participants (50%) and 99 participants (62%) stretching before and after a standard marathon respectively. The most commonly reported muscle groups included in stretching regimes were the calves (n = 130; 43%) hamstrings (n = 125; 42%) and quadriceps (n = 118; 39%). Only 79 participants (27%) reported that they hold each stretch for 25 to 30 seconds (Table 3-15). Participants performed an average of  $3 \pm 2$  repetitions of each stretch. Participants used stretching as a recovery modality for  $4 \pm 3$  d.wk<sup>-1</sup> during regular training and for  $3 \pm 6$  days after a race.

Table 3-14: Pattern of use of stretching and muscle groups included in the stretching regime. Data are presented as numbers (n) and percentages (%) of the total number of participants using stretching (n = 299), or the number of participants using stretching during training (n = 203) and races (n = 159) respectively.

Stretching (n = 299)					
Variable	Always	Often	Sometimes	Rarely	Total
Pattern of use during training (n = 203)					
Before training	34 (17%)	46 (23%)	48 (24%)	34 (17%)	162 (80%)
During training	11 (5%)	27 (13%)	51 (25%)	54 (27%)	143 (70%)
After training	76 (37%)	66 (33%)	41 (20%)	12 (6%)	195 (96%)
When very tired	16 (8%)	38 (19%)	60 (30%)	41 (20%)	155 (76%)
Training hard	47 (23%)	64 (32%)	47 (23%)	15 (7%)	173 (85%)
When injured	51 (25%)	64 (32%)	46 (23%)	16 (8%)	177 (87%)
When in pain	34 (17%)	62 (31%)	45 (22%)	22 (11%)	163 (80%)
Depending on the day/ no regular pattern	14 (7%)	24 (12%)	49 (24%)	28 (14%)	115 (57%)
Pattern of use during races (n = 159)					
Before a half marathon	44 (28%)	32 (20%)	19 (12%)	15 (9%)	110 (69%)
During a half marathon	10 (6%)	10 (6%)	15 (9%)	27 (17%)	62 (39%)
After a half marathon	60 (38%)	35 (22%)	29 (18%)	10 (6%)	134 (84%)
Before a standard marathon	37 (23%)	24 (13%)	12 (8%)	7 (4%)	80 (50%)
During a standard marathon	13 (8%)	13 (8%)	18 (11%)	11 (7%)	55 (35%)
After a standard marathon	48 (30%)	26 (16%)	20 (13%)	5 (3%)	99 (62%)
Before an ultramarathon	32 (20%)	21 (13%)	11 (7%)	7 (4%)	71 (45%)
During an ultramarathon	12 (8%)	22 (14%)	11 (7%)	15 (9%)	60 (38%)
After an ultramarathon	42 (26%)	19 (12%)	18 (11%)	3 (2%)	82 (52%)
When injured	36 (23%)	45 (28%)	33 (20%)	12 (8%)	126 (79%)
When in pain	36 (23%)	34 (21%)	46 (29%)	12 (8%)	128 (80%)
When very tired	27 (17%)	27 (17%)	45 (29%)	19 (12%)	118 (74%)
After racing hard	51 (32%)	51 (32%)	34 (21%)	6 (4%)	142 (89%)
Depending on the day/ no regular pattern	16 (10%)	19 (12%)	38 (24%)	6 (4%)	79 (50%)
Muscle groups included in the stretching regimen (n = 299)					
Quadriceps	118 (39%)	100 (33%)	58 (19%)	13 (0.4%)	289 (97%)
Hamstrings	125 (42%)	102 (34%)	51 (17%)	12 (0.4%)	290 (97%)
Calves	130 (43%)	93 (31%)	50 (17%)	18 (1%)	291 (97%)
Groin	76 (25%)	69 (23%)	64 (21%)	50 (17%)	259 (87%)
Buttocks	81 (27%)	84 (28%)	59 (20%)	43 (14%)	267 (89%)
Back	53 (18%)	74 (25%)	87 (29%)	49 (16%)	263 (88%)
Arms	32 (11%)	36 (12%)	77 (26%)	88 (29%)	233 (78%)
Neck	30 (10%)	33 (11%)	75 (25%)	98 (33%)	236 (79%)



**Table 3-15: Average stretching duration and frequency. Categorical data are presented as number (n) and percentages (%) of participants using stretches (n = 299), and numeric data are presented as mean  $\pm$  standard deviation (SD).**

<b>Average duration of stretching (n = 299)</b>	
<b>Variable</b>	<b>Number of participants</b>
<b>1 to 5 seconds</b>	11 (4%)
<b>6 to 10 seconds</b>	50 (17%)
<b>11 to 15 seconds</b>	39 (13%)
<b>16 to 20 seconds</b>	53 (18%)
<b>21 to 25 seconds</b>	11 (4%)
<b>26 to 30 seconds</b>	79 (27%)
<b>31 to 35 seconds</b>	16 (5%)
<b>36 to 40 seconds</b>	6 (2%)
<b>41 to 45 seconds</b>	1 (0.3%)
<b>46 to 50 seconds</b>	3 (1%)
<b>51 to 55 minutes</b>	7 (2%)
<b>56 to 60 seconds</b>	9 (3%)
<b>Longer than 60 seconds</b>	1 (0.3%)
<b>"I do dynamic stretching, so I don't hold it"</b>	12 (4%)
<b>Frequency of stretching</b>	
<b>Variable</b>	<b>Mean <math>\pm</math> SD</b>
<b>Number of repetitions per stretch (n = 299)</b>	3 $\pm$ 2
<b>Weekly frequency (n = 299)</b>	4 $\pm$ 3
<b>Number of days after a race (n = 134)</b>	3 $\pm$ 6

#### **d) Protein**

The pattern of use of protein is shown in Table 3-16. Protein was used by 261 participants as a recovery modality, with the most frequent use being after training (n = 134; 97%) and after standard marathons (n = 97; 74%). The use of protein as a recovery modality for injury and pain conditions was consistently low during training (use for pain = 57%; use for injury = 64%) and racing (use for pain = 60% and use for injury = 56%) respectively. The most common sources of protein as a recovery modality included eggs (n = 226; 87%), a normal meal (n = 224; 86%), and milk (n = 187; 72%). Participants consumed extra protein for an average of 7  $\pm$  21 days before a race and for 3  $\pm$  6 days after a race. In addition, 67 participants (26%) reported using protein within the first 30 minutes after completing a race (Table 3-17).

Table 3-16: Pattern of use of protein and sources of protein. Data are presented as numbers (n) and percentages (%) of the total number of participants using protein (n = 261), or the number of participants using protein during training (n = 138 and races (n = 131) respectively.

Protein (n = 261)					
Variable	Always	Often	Sometimes	Rarely	Total
Pattern of use during training (n = 138)					
Before training	19 (14%)	29 (21%)	29 (21%)	22 (16%)	99 (72%)
During training	6 (4%)	17 (12%)	23 (17%)	34 (25%)	80 (58%)
After training	39 (28%)	76 (55%)	16 (12%)	3 (2%)	134 (97%)
When very tired	12 (9%)	37 (27%)	30 (22%)	21 (15%)	100 (72%)
When training hard	33 (24%)	65 (47%)	20 (14%)	2 (1%)	120 (87%)
When injured	11 (8%)	25 (18%)	22 (16%)	31 (22%)	89 (64%)
When in pain	10 (7%)	19 (14%)	20 (14%)	29 (21%)	78 (57%)
Depending on the day/ no regular pattern	11 (8%)	10 (7%)	26 (19%)	17 (12%)	64 (46%)
Pattern of use for races (n = 131)					
Before a half marathon	25 (19%)	22 (17%)	20 (15%)	21 (16%)	88 (67%)
During a half marathon	7 (5%)	8 (6%)	16 (12%)	27 (21%)	58 (44%)
After a half marathon	31 (24%)	33 (25%)	22 (17%)	10 (8%)	96 (73%)
Before a standard marathon	32 (24%)	28 (21%)	20 (15%)	9 (7%)	88 (67%)
During a standard marathon	12 (9%)	15 (11%)	18 (14%)	16 (12%)	61 (47%)
After a standard marathon	38 (29%)	39 (30%)	16 (12%)	4 (0.3%)	97 (74%)
Before an ultramarathon	36 (27%)	26 (20%)	10 (8%)	7 (5%)	79 (60%)
During an ultramarathon	19 (15%)	20 (15%)	13 (10%)	14 (11%)	66 (50%)
After an ultramarathon	36 (27%)	35 (27%)	11 (8%)	2 (0.2%)	84 (64%)
When injured	12 (9%)	12 (9%)	21 (16%)	28 (21%)	73 (56%)
When in pain	13 (10%)	13 (10%)	27 (21%)	25 (19%)	78 (60%)
When very tired	15 (11%)	26 (20%)	30 (23%)	24 (18%)	95 (73%)
When racing hard	29 (22%)	51 (39%)	28 (21%)	9 (7%)	117 (89%)
Depending on the day/ no regular pattern	7 (5%)	3 (0.2%)	20 (15%)	14 (11%)	44 (34%)
Sources of protein (n = 261)					
Normal meal with protein	43 (16%)	75 (29%)	81 (31%)	26 (10%)	225 (86%)
Normal meal with an increased amount of protein	28 (11%)	91 (35%)	71 (27%)	34 (13%)	224 (86%)
Milk	32 (20%)	58 (22%)	49 (19%)	48 (18%)	187 (72%)
Flavoured milk	26 (10%)	62 (24%)	50 (19%)	29 (11%)	167 (64%)
Eggs	43 (16%)	95 (36%)	61 (23%)	27 (10%)	226 (87%)
Protein bar	7 (2%)	45 (17%)	54 (20%)	53 (20%)	159 (61%)
Protein shake or drink	41 (16%)	78 (30%)	40 (16%)	27 (10%)	186 (71%)
Other	7 (2%)	20 (8%)	23 (9%)	42 (16%)	92 (35%)

**Table 3-17: Pattern of post-race protein use. Data are presented as numbers (n) and percentages (%) of the total number of participants using protein after a race (n = 261).**

<b>Protein use after a race</b>	<b>Number of participants (n = 261)</b>
<b>Within the first 30 minute post-race</b>	67 (26%)
<b>31 to 60 minutes post-race</b>	41 (16%)
<b>61 to 90 minutes post-race</b>	16 (6%)
<b>91 minutes to 2 hours post-race</b>	5 (2%)
<b>More than 2 hours post-race</b>	5 (2%)
<b>At my next meal</b>	29 (11%)
<b>Only when I am hungry</b>	4 (2%)
<b>Only when I feel like it</b>	9 (3%)
<b>Only when I am tired</b>	0 (0%)

#### **e) Cryotherapy**

The pattern of use of cryotherapy is shown in Table 3-18. The use of cryotherapy was reported by 209 participants, with cryotherapy being the most commonly used during injury (n = 182; 87%) and pain conditions (n = 173; 83%). The predominant method of application of cryotherapy was ice or icepacks (n = 193; 94%). A high proportion (n = 182; 87%) use cryotherapy when they are injured or have pain (n = 173; 83%) (Table 3-18). Ice or icepacks are used “always” (n = 63; 31%) or “sometimes” (n = 75; 36%) by participants. One hundred and forty-one participants (67%) reported that they apply cryotherapy by swimming in a pool or in the sea. Thirty six percent of participants applied cryotherapy for between 16 and 30 minutes (Table 3-19). On average, participants applied cryotherapy once a day for  $2 \pm 1$  days after a race.

**Table 3-18: Pattern of use of cryotherapy and the methods of application of cryotherapy. Data are presented as numbers (n) and percentages (%) of the total number of participants using cryotherapy (n = 209).**

<b>Cryotherapy (n = 209)</b>					
<b>Variable</b>	<b>Always</b>	<b>Often</b>	<b>Sometimes</b>	<b>Rarely</b>	<b>Total</b>
<b>Pattern of use</b>					
<b>For an ultramarathon</b>	26 (13%)	47 (24%)	51 (62%)	10 (5%)	134 (64%)
<b>For a standard marathon</b>	18 (6%)	43 (22%)	64 (33%)	11 (6%)	136 (65%)
<b>For a half marathon</b>	7 (4%)	23 (12%)	65 (33%)	42 (21%)	137 (66%)
<b>Weekly, during normal training</b>	3 (2%)	19 (10%)	42 (23%)	47 (26%)	111 (53%)
<b>When injured</b>	48 (24%)	71 (36%)	52 (27%)	11 (6%)	182 (87%)
<b>Only when in pain</b>	29 (15%)	68 (35%)	68 (35%)	8 (4%)	173 (83%)
<b>Only when very tired</b>	1 (1%)	12 (7%)	22 (12%)	38 (21%)	73 (35%)
<b>When training and racing hard</b>	5 (3%)	35 (19%)	59 (31%)	31 (16%)	130 (62%)
<b>Depends on the day/ no regular pattern</b>	7 (4%)	9 (5%)	24 (14%)	19 (11%)	59 (28%)
<b>Method of cryotherapy application</b>					
<b>Ice/ice packs</b>	42 (20%)	63 (31%)	75 (36%)	14 (7%)	194 (93%)
<b>Cold/ice water</b>	8 (4%)	32 (16%)	43 (20%)	32 (16%)	115 (55%)
<b>Cold shower</b>	7 (3%)	15 (7%)	28 (4%)	42 (21%)	92 (44%)
<b>Cold bath</b>	3 (1%)	12 (6%)	31 (15%)	31 (15%)	77 (37%)
<b>Swimming pool/sea</b>	10 (5%)	24 (12%)	69 (33%)	38 (19%)	141 (67%)
<b>Cold rub</b>	7 (3%)	13 (6%)	10 (5%)	20 (10%)	50 (24%)
<b>Ice gels</b>	8 (4%)	24 (12%)	43 (21%)	22 (11%)	97 (46%)

**Table 3-19: Duration of cryotherapy intervention. Data are presented as numbers (n) and percentages (%) of the total number of participants using cryotherapy (n = 209).**

Variable	Number of participants (n = 209)
1 to 5 minutes	31 (15%)
6 to 10 minutes	75 (36%)
11 to 15 minutes	37 (18%)
16 to 20 minutes	44 (21%)
21 to 25 minutes	4 (2%)
26 to 30 minutes	13 (13%)
31 to 35 minutes	3 (1%)

**f) Anti-inflammatory medication**

The pattern of use of anti-inflammatory medication is shown in Table 3-20. The use of anti-inflammatory medication as a recovery modality was reported by 200 participants, with 55 participants using anti-inflammatory medication during training and 143 participants using anti-inflammatory medication during races. During training, anti-inflammatory medication was commonly used for injury (n = 48; 87%) or pain conditions (n = 50; 91%). During races, anti-inflammatory medication was commonly used for injury (n = 113; 79%) or fatigue (n = 119; 83%), while 39 participants (27%) reported using anti-inflammatory medication with no specific pattern. There was also high reported use of anti-inflammatory medication after races, ranging from 48% of participants after a half marathon to 67% of participants after an ultramarathon. Cataflam D© (n = 107; 54%), Voltaren© (n = 101; 51%) and Myprodol© (n = 100; 50%) were the most commonly used anti-inflammatory medications. Table 3-21 contains more detail about the frequency of use of anti-inflammatory medication during training and races. Participants reported use of anti-inflammatory medication for a mean of  $2 \pm 2$  days after a race.

Table 3-20: Pattern of use of anti-inflammatory medication, commonly used medication, and methods of delivery of anti-inflammatory medication. Data are presented as numbers (n) and percentages (%) of the total number of the participants using anti-inflammatory medication (n = 200), or the number of participants using anti-inflammatory medication during training (n = 55) and races (n = 143) respectively.

Anti-inflammatory medication (n = 200)					
Variable	Always	Often	Sometimes	Rarely	Total
Pattern of use during training (n = 55)					
Before training	3 (5%)	0 (0%)	16 (29%)	9 (16%)	28 (51%)
During training	1 (2%)	1 (2%)	8 (15%)	13 (24%)	23 (42%)
After training	3 (5%)	12 (22%)	20 (36%)	6 (11%)	41 (75%)
When very tired	1 (2%)	1 (2%)	5 (9%)	10 (18%)	17 (31%)
When training hard	1 (2%)	4 (7%)	9 (16%)	9 (16%)	23 (42%)
When injured	9 (16%)	20 (36%)	17 (31%)	2 (5%)	48 (87%)
When in pain	11 (20%)	16 (29%)	21 (38%)	2 (5%)	50 (91%)
Depending on the day/ no regular pattern	3 (5%)	2 (5%)	13 (24%)	3 (5%)	21 (38%)
Pattern of use during races (n = 143)					
Before a half marathon	3 (2%)	4 (3%)	12 (8%)	16 (11%)	35 (25%)
During a half marathon	1 (1%)	1 (1%)	5 (3%)	14 (10%)	21 (15%)
After a half marathon	3 (2%)	11 (8%)	31 (22%)	24 (17%)	69 (48%)
Before a standard marathon	2 (1%)	4 (3%)	15 (10%)	16 (11%)	37 (26%)
During a standard marathon	5 (3%)	6 (4%)	17 (12%)	22 (15%)	50 (35%)
After a standard marathon	6 (4%)	22 (15%)	52 (36%)	14 (10%)	94 (66%)
Before an ultramarathon	4 (3%)	7 (5%)	17 (12%)	13 (9%)	41 (27%)
During an ultramarathon	9 (6%)	10 (7%)	22 (15%)	18 (13%)	59 (41%)
After an ultramarathon	14 (10%)	28 (20%)	45 (31%)	9 (6%)	96 (67%)
When injured	25 (17%)	38 (27%)	42 (29%)	8 (6%)	113 (79%)
When in pain	5 (3%)	9 (6%)	20 (14%)	24 (17%)	58 (41%)
When very tired	19 (13%)	42 (29%)	50 (35%)	8 (6%)	119 (83%)
Depending on the day/ no regular pattern	6 (4%)	6 (4%)	17 (12%)	10 (7%)	39 (27%)
Commonly used anti-inflammatory medication (n = 200)					
Advil ©	3 (2%)	6 (3%)	4 (2%)	8 (4%)	21 (11%)
Aspirin ©	0 (0%)	4 (2%)	19 (10%)	14 (7%)	37 (19%)
Cataflam D ©	15 (8%)	24 (12%)	45 (22%)	23 (12%)	107 (54%)
Celebrex ©	3 (2%)	4 (2%)	6 (3%)	9 (5%)	22 (11%)
Ibuprofen ©	8 (4%)	22 (11%)	36 (18%)	19 (10%)	85 (43%)
Myprodol ©	7 (4%)	22 (11%)	44 (22%)	27 (14%)	100 (50%)
Norflex ©	3 (2%)	6 (3%)	2 (1%)	18 (9%)	29 (15%)
Panamor ©	5 (3%)	9 (5%)	16 (8%)	3 (2%)	33 (17%)
Tramal ©	2 (1%)	10 (5%)	17 (9%)	7 (4%)	36 (18%)
Transact patch ©	5 (3%)	20 (10%)	33 (17%)	23 (12%)	81 (41%)
Voltaren ©	4 (2%)	21 (11%)	48 (24%)	28 (14%)	101 (51%)
Method of delivery (n = 200)					
Tablet	67 (34%)	46 (23%)	59 (30%)	14 (7%)	186 (93%)
Suppository	2 (1%)	0 (0%)	4 (2%)	4 (2%)	10 (5%)
Gel/cream	13 (7%)	33 (17%)	58 (29%)	15 (8%)	119 (60%)
Patch	6 (3%)	17 (9%)	43 (22%)	20 (10%)	86 (43%)
Injection	3 (2%)	4 (2%)	14 (7%)	27 (14%)	48 (24%)

**Table 3-21: Frequency of use of anti-inflammatory medication during races and training. Data are presented as the number and percentages (%) of participants using anti-inflammatory medication during races (n = 143) and training (n = 55).**

<b>Anti-inflammatory medication (n = 200)</b>	
<b>Frequency of use during races (n = 143)</b>	
<b>Variable</b>	<b>Number of participants</b>
Every 1 to 60 minutes	3 (2%)
Every 61 minutes to 2 hours	7 (5%)
Every 3 hours	10 (7%)
Every 4 hours	8 (6%)
Every 5 hours	1 (1%)
Every 6 hours	1 (1%)
Every 7 hours	0 (0%)
Every 8 hours or more	3 (2%)
No specific pattern	12 (8%)
Only when I feel pain	34 (24%)
Never	64 (45%)
<b>Frequency of use during training (n = 55)</b>	
Once a day	8 (15%)
Twice a day	4 (7%)
Three times a day	1 (2%)
Only when I feel pain	26 (47%)
No specific pattern	10 (18%)
Never	7 (13%)

#### **g) Massage**

The pattern of use of massage is shown in Table 3-22. The use of massage as a recovery modality was reported by 199 participants, with massage being most commonly used during injury (n = 155; 78%), pain conditions (n = 149; 75%) or for an ultramarathon (n = 144; 57%). The majority of participants consulted physiotherapists (n = 130; 65%) or sport massage therapists (n = 128; 64%). Massage was used as a recovery modality for an average of  $2 \pm 1$  days after a race. The most common duration of a massage as a recovery modality was 56 to 60 minutes, as shown in Table 3-23.

**Table 3-22: Pattern of use of massage and type of massage therapist. Data are presented as numbers (n) and percentages (%) of the total number of participants using massage (n = 199).**

<b>Massage (n = 199)</b>					
<b>Variable</b>	<b>Always</b>	<b>Often</b>	<b>Sometimes</b>	<b>Rarely</b>	<b>Total</b>
<b>Pattern of use</b>					
<b>For an ultramarathon</b>	34 (18%)	30 (15%)	38 (20%)	12 (6%)	114 (57%)
<b>For a standard marathon</b>	23 (12%)	30 (15%)	54 (28%)	23 (12%)	130 (65%)
<b>For a half marathon</b>	8 (4%)	15 (8%)	45 (23%)	34 (18%)	102 (51%)
<b>Weekly, during normal training</b>	6 (3%)	6 (3%)	35 (18%)	31 (16%)	78 (39%)
<b>When injured</b>	49 (25%)	42 (22%)	48 (25%)	16 (8%)	155 (78%)
<b>Only when in pain</b>	25 (13%)	52 (27%)	54 (28%)	18 (9%)	149 (75%)
<b>Only when very tired</b>	7 (4%)	14 (7%)	43 (22%)	28 (14%)	92 (46%)
<b>When training and racing hard</b>	16 (8%)	36 (19%)	56 (29%)	19 (10%)	127 (64%)
<b>Depends on the day/ no regular pattern</b>	14 (7%)	12 (6%)	30 (15%)	10 (2%)	66 (33%)
<b>Type of massage therapist</b>					
<b>Friend/family</b>	1 (1%)	16 (8%)	23 (12%)	13 (7%)	53 (27%)
<b>Physiotherapist</b>	33 (17%)	29 (15%)	43 (22%)	25 (13%)	130 (65%)
<b>Lynotherapist</b>	6 (3%)	5 (3%)	11 (5%)	10 (5%)	32 (16%)
<b>Chiropractor</b>	3 (1%)	8 (4%)	28 (14%)	12 (6%)	51 (26%)
<b>Sports massage therapist</b>	41 (21%)	31 (16%)	45 (23%)	11 (6%)	128 (64%)
<b>Beautician</b>	2 (1%)	6 (3%)	14 (7%)	5 (3%)	27 (14%)
<b>Thai massage therapist</b>	2 (1%)	6 (3%)	10 (5%)	8 (4%)	26 (13%)
<b>Foam roller</b>	2 (1%)	2 (3%)	0 (0%)	0 (0%)	4 (2%)



**Table 3-23: Duration of massage. Data are presented as numbers (n) and percentages (%) of the total number of the participants using massage (n = 199).**

<b>Massage (n = 199)</b>	
<b>Variable</b>	<b>Number of participants</b>
<b>1 to 5 minutes</b>	3 (2%)
<b>6 to 10 minutes</b>	4 (2%)
<b>11 to 15 minutes</b>	6 (3%)
<b>16 to 20 minutes</b>	10 (5%)
<b>21 to 25 minutes</b>	2 (1%)
<b>26 to 30 minutes</b>	29 (15%)
<b>31 to 35 minutes</b>	9 (5%)
<b>36 to 40 minutes</b>	10 (5%)
<b>41 to 45 minutes</b>	20 (10%)
<b>46 to 50 minutes</b>	11 (6%)
<b>51 to 55 minutes</b>	4 (2%)
<b>56 to 60 minutes</b>	75 (39%)
<b>More than 60 minutes</b>	11 (6%)

#### **h) Vitamins and minerals**

The pattern of use of vitamins and minerals is shown in Table 3-24. The use of vitamins or minerals as a recovery modality was reported by 196 participants, with vitamins or minerals being most commonly used during weekly training sessions (n = 166; 85%) and before an ultramarathon (n = 130; 66%). Common types of vitamins and minerals included multivitamins (n = 172; 88%), magnesium (n = 172; 88%) and vitamin C (n = 166; 86%). Vitamins or minerals were used for an average of  $7 \pm 9$  days before a race and for  $5 \pm 8$  days after.

**Table 3-24: Pattern of use and type of vitamins and minerals. Data are presented as numbers (n) and percentages (%) of the total number of participants using vitamins and minerals (n = 196).**

<b>Vitamins and minerals (n = 196)</b>					
<b>Variable</b>	<b>Always</b>	<b>Often</b>	<b>Sometimes</b>	<b>Rarely</b>	<b>Total</b>
<b>Pattern of use</b>					
<b>For an ultramarathon</b>	84 (47%)	30 (17%)	13 (7%)	3 (2%)	130 (66%)
<b>For a standard marathon</b>	80 (44%)	36 (20%)	18 (10%)	6 (3%)	140 (71%)
<b>For a half marathon</b>	76 (42%)	20 (11%)	38 (21%)	15 (8%)	149 (76%)
<b>Weekly, during normal training</b>	87 (47%)	35 (19%)	29 (16%)	15 (8%)	166 (85%)
<b>When injured</b>	59 (35%)	19 (11%)	23 (14%)	20 (12%)	121 (62%)
<b>Only when in pain</b>	54 (32%)	18 (11%)	22 (13%)	24 (14%)	118 (60%)
<b>Only when very tired</b>	68 (39%)	33 (19%)	26 (15%)	12 (7%)	139 (71%)
<b>When training and racing hard</b>	73 (42%)	37 (21%)	27 (16%)	9 (5%)	146 (74%)
<b>Depends on the day/ no regular pattern</b>	32 (20%)	7 (4%)	20 (13%)	12 (8%)	71 (36%)
<b>Type of vitamin or mineral</b>					
<b>Multivitamins</b>	77 (41%)	42 (22%)	39 (21%)	14 (7%)	172 (88%)
<b>Vitamin A</b>	20 (10%)	14 (7%)	34 (18%)	35 (18%)	103 (53%)
<b>Vitamin B12</b>	33 (17%)	38 (20%)	40 (21%)	28 (15%)	139 (71%)
<b>Vitamin C</b>	65 (34%)	44 (23%)	40 (21%)	17 (9%)	166 (85%)
<b>Vitamin D</b>	28 (15%)	24 (12%)	41 (21%)	29 (15%)	122 (62%)
<b>Vitamin E</b>	22 (11%)	20 (10%)	39 (20%)	31 (16%)	112 (57%)
<b>Calcium</b>	55 (28%)	36 (19%)	35 (18%)	21 (11%)	147 (75%)
<b>Magnesium</b>	71 (37%)	51 (26%)	37 (19%)	13 (7%)	172 (88%)
<b>Iron</b>	33 (17%)	25 (13%)	43 (22%)	25 (13%)	126 (64%)

#### **i) Compression**

The pattern of use of compression is shown in Table 3-25. The use of compression as a recovery modality was reported by 175 participants. Overall, the self-reported use of compression was higher for races (n = 97), compared to training (n = 88). Compression was used most frequently during training (n = 85; 97%) and during races (60% to 76% for ultramarathon and half marathons respectively). Participants mainly used compression socks (n = 135; 77%) or compression pants (n = 85; 49%). Of the participants who used compression for races, 12 participants (12%) applied compression an hour before the race while 52 participants (56%) applied compression for between one and twelve hours after the race (Table 3-26).

**Table 3-25: Pattern of use and type of compression.** Data are presented as numbers (n) and percentages (%) of the total number of the participants using compression during training (n = 88) and races (n = 97) respectively.

<b>Compression (n = 175)</b>					
<b>Variable</b>	<b>Always</b>	<b>Often</b>	<b>Sometimes</b>	<b>Rarely</b>	<b>Total</b>
<b>Pattern of use during training (n = 88)</b>					
<b>Before training</b>	0 (0%)	6 (7%)	14 (16%)	10 (11%)	30 (34%)
<b>During training</b>	12 (14%)	37 (42%)	29 (33%)	7 (8%)	85 (97%)
<b>After training</b>	5 (6%)	26 (30%)	23 (26%)	10 (11%)	64 (73%)
<b>When very tired</b>	6 (7%)	10 (11%)	11 (10%)	15 (17%)	42 (48%)
<b>When training hard</b>	11 (10%)	27 (31%)	25 (28%)	6 (7%)	69 (78%)
<b>When injured</b>	15 (17%)	30 (34%)	16 (18%)	6 (7%)	67 (76%)
<b>When in pain</b>	17 (19%)	26 (30%)	19 (22%)	6 (7%)	68 (77%)
<b>Depending on the day/ no regular pattern</b>	2 (2%)	10 (11%)	11 (10%)	8 (2%)	31 (35%)
<b>Pattern of use during races (n = 97)</b>					
<b>Before a half marathon</b>	3 (3%)	8 (8%)	11 (11%)	6 (6%)	28 (29%)
<b>During a half marathon</b>	19 (20%)	31 (32%)	16 (16%)	8 (8%)	74 (76%)
<b>After a half marathon</b>	9 (9%)	12 (12%)	19 (20%)	13 (13%)	53 (55%)
<b>Before a standard marathon</b>	4 (4%)	8 (8%)	11 (11%)	8 (8%)	31 (32%)
<b>During a standard marathon</b>	30 (31%)	21 (22%)	10 (10%)	4 (4%)	65 (67%)
<b>After a standard marathon</b>	15 (15%)	20 (21%)	14 (14%)	4 (4%)	53 (55%)
<b>Before an ultramarathon</b>	7 (7%)	6 (6%)	9 (9%)	5 (5%)	27 (28%)
<b>During an ultramarathon</b>	29 (30%)	21 (22%)	6 (6%)	2 (2%)	58 (60%)
<b>After an ultramarathon</b>	21 (22%)	15 (15%)	6 (6%)	4 (4%)	46 (47%)
<b>When injured</b>	17 (18%)	23 (24%)	18 (19%)	3 (3%)	61 (63%)
<b>When in pain</b>	16 (17%)	22 (23%)	20 (21%)	3 (3%)	61 (63%)
<b>When very tired</b>	10 (10%)	12 (12%)	19 (20%)	6 (6%)	47 (48%)
<b>When racing hard</b>	20 (21%)	31 (32%)	21 (22%)	10 (10%)	82 (85%)
<b>Depending on the day/ no regular pattern</b>	5 (5%)	8 (8%)	9 (9%)	4 (4%)	26 (27%)
<b>Type of compression (n = 175)</b>					
<b>Full body compression suit</b>	0 (0%)	2 (1%)	2 (1%)	4 (2%)	8 (5%)
<b>Compression pants/leggings (up to hips)</b>	9 (5%)	37 (21%)	31 (18%)	8 (5%)	85 (49%)
<b>Compression socks (lower than knees)</b>	37 (21%)	56 (32%)	29 (17%)	13 (7%)	135 (77%)
<b>Compression bandages</b>	2 (1%)	5 (3%)	17 (10%)	16 (9%)	40 (23%)

**Table 3-26: Duration of compression used before and after a race. Data are expressed as numbers (n) and percentages (%) of the total number of participants using compression for races (n = 97).**

<b>Duration of compression before a race (n = 97)</b>	
<b>Variable</b>	<b>Number of participants</b>
<b>Less than 1 hour</b>	12 (12%)
<b>1 to 2 hours</b>	6 (6%)
<b>3 to 6 hours</b>	8 (8%)
<b>7 to 12 hours</b>	8 (8%)
<b>13 to 18 hours</b>	0 (0%)
<b>19 to 24 hours</b>	3 (3%)
<b>25 to 48 hours</b>	2 (2%)
<b>More than 48 hours</b>	1 (1%)
<b>Duration of compression after a race (n = 97 )</b>	
<b>Less than 1 hour</b>	7 (7%)
<b>1 to 2 hours</b>	21 (22%)
<b>3 to 6 hours</b>	17 (18%)
<b>7 to 12 hours</b>	11 (11%)
<b>13 to 18 hours</b>	4 (4%)
<b>19 to 24 hours</b>	8 (8%)
<b>25 to 30 hours</b>	4 (4%)
<b>31 to 36 hours</b>	3 (3%)
<b>37 to 48 hours</b>	1 (1%)
<b>More than 48 hours</b>	1 (1%)

#### **j) Carbohydrates**

The pattern of use of carbohydrates is shown in Table 3-27. Carbohydrates were used as a recovery modality by 162 participants. Overall, the self-reported use of carbohydrates was higher for races ( $n = 130$ ), compared to training ( $n = 73$ ). Of participants that used carbohydrates for races, between 67% to 75% of participants consumed carbohydrates before, during and after standard marathons and ultramarathons, while 45 participants (35%) reported using carbohydrates when racing hard. The majority of participants consumed a normal meal with some additional carbohydrates ( $n = 150$ ; 93%), while 142 participants (88%) obtained carbohydrates from pasta and 143 participants (88%) sourced carbohydrates from fruit. Of participants that used carbohydrates for races, 37 participants (23%) consumed carbohydrates within the first 30 minutes after a race, and 30 participants (19%) used carbohydrates between 31 minutes to 60 minutes after a race (Table 3-28). In addition, only 50 participants (39%) reported sometimes “carbo-loading”. On average participants consumed carbohydrates for  $3 \pm 3$  days before a race and for  $2 \pm 2$  days after a race.

Table 3-27: Pattern of use of carbohydrates. Data are presented as numbers (n) and percentages (%) of the total number of the participants consuming carbohydrates (n = 162), or the number of participants using carbohydrates during training (n = 73) and races (n = 130) respectively.

Carbohydrates (n = 162)					
Variable	Always	Often	Sometimes	Rarely	Total
Pattern of use during training (n = 73)					
Before training	8 (11%)	30 (41%)	22 (31%)	5 (7%)	65 (89%)
During training	7 (10%)	19 (26%)	26 (36%)	11 (15%)	63 (86%)
After training	11 (15%)	33 (45%)	19 (26%)	5 (7%)	68 (93%)
When very tired	7 (10%)	22 (31%)	20 (27%)	11 (15%)	60 (82%)
When training hard	14 (19%)	36 (49%)	12 (16%)	1 (1%)	63 (86%)
When injured	3 (4%)	8 (11%)	17 (23%)	22 (31%)	50 (68%)
When in pain	1 (1%)	8 (11%)	14 (19%)	27 (37%)	50 (68%)
Depending on the day/ no regular pattern	4 (5%)	4 (5%)	23 (32%)	8 (11%)	39 (53%)
Pattern of use during races (n = 130)					
Before a half marathon	16 (12%)	34 (26%)	26 (20%)	26 (20%)	102 (78%)
During a half marathon	25 (19%)	24 (18%)	23 (18%)	26 (20%)	98 (75%)
After a half marathon	19 (15%)	25 (19%)	30 (23%)	28 (22%)	102 (78%)
Before a standard marathon	39 (30%)	45 (35%)	11 (8%)	3 (2%)	98 (75%)
During a standard marathon	39 (30%)	29 (22%)	17 (13%)	11 (8%)	96 (74%)
After a standard marathon	32 (25%)	31 (24%)	21 (16%)	12 (9%)	96 (74%)
Before an ultramarathon	46 (35%)	35 (27%)	10 (8%)	1 (1%)	92 (71%)
During an ultramarathon	41 (32%)	27 (21%)	15 (12%)	6 (5%)	89 (68%)
After an ultramarathon	35 (27%)	30 (23%)	13 (10%)	9 (7%)	87 (67%)
When in pain	1 (1%)	11 (8%)	18 (14%)	32 (25%)	62 (48%)
When very tired	7 (5%)	27 (21%)	31 (24%)	23 (18%)	88 (68%)
When racing hard	19 (15%)	45 (35%)	28 (22%)	10 (8%)	102 (78%)
Depending on the day/ no regular pattern	2 (2%)	6 (5%)	28 (22%)	12 (9%)	48 (37%)
Type of carbohydrate (n = 162)					
Normal meal with carbohydrates	27 (17%)	73 (45%)	42 (26%)	8 (5%)	150 (93%)
Normal meal with increased carbohydrates	10 (6%)	46 (28%)	57 (35%)	26 (16%)	139 (86%)
Pasta	11 (7%)	70 (43%)	40 (25%)	21 (13%)	142 (88%)
Rice	10 (6%)	46 (28%)	46 (28%)	31 (19%)	133 (82%)
Potato	13 (8%)	61 (38%)	39 (24%)	27 (17%)	140 (86%)
Sandwich	9 (6%)	44 (27%)	51 (31%)	30 (19%)	134 (83%)
Fruit	30 (19%)	59 (36%)	40 (25%)	14 (9%)	143 (88%)
GU or equivalent	11 (7%)	41 (25%)	39 (24%)	20 (12%)	111 (69%)
Shake	7 (4%)	27 (17%)	36 (22%)	32 (20%)	102 (63%)
Sports drink	18 (11%)	24 (15%)	48 (30%)	21 (13%)	111 (69%)
Soda drink	7 (4%)	25 (15%)	32 (20%)	33 (20%)	97 (60%)
Fruit juice	11 (7%)	27 (17%)	43 (27%)	31 (19%)	112 (69%)

**Table 3-28: The frequency of carbohydrate use before a race and the timing of carbohydrate use after a race. Data are presented as numbers (n) and percentages of the total number of participants using carbohydrates for races (n = 130).**

<b>Frequency of carbohydrate use before a race (n = 130)</b>	
<b>Variable</b>	<b>Number of participants</b>
<b>Always</b>	19 (15%)
<b>Often</b>	43 (33%)
<b>Sometimes</b>	50 (39%)
<b>Rarely</b>	24 (18%)
<b>Never</b>	23 (18%)
<b>Timing of carbohydrate use after a race (n = 130)</b>	
<b>Variable</b>	<b>Number of participants</b>
<b>Within 30 minute post race</b>	37 (29%)
<b>31 to 60 minutes post race</b>	30 (23%)
<b>61 to 90 minutes post race</b>	16 (12%)
<b>91 minutes to 2 hours post race</b>	9 (7%)
<b>More than 2 hours post race</b>	4 (3%)
<b>At my next meal</b>	14 (11%)
<b>Only when I am hungry</b>	7 (5%)
<b>Only when I feel like it</b>	8 (6%)
<b>Only when I am tired</b>	1 (1%)

#### **k) Heat**

The pattern of use of heat is shown in Table 3-29. The use of heat as a recovery modality was reported by 122 participants, with heat being most commonly used for injuries (n = 110; 90%) and pain conditions (n = 108; 89%). Heat was mainly applied through participants' having a hot bath (n = 99; 81%) or hot shower (n = 98; 80%). A third of participants (n = 40; 33%) used heat for between six and ten minutes (Table 3-30). On average, heat was applied  $2 \pm 1$  times a day for  $2 \pm 1$  days after a race.

**Table 3-29: Pattern of use of heat therapy. Data are presented as numbers (n) and percentages (%) of the total number of participants using heat (n = 122).**

<b>Heat (n = 122)</b>					
<b>Variable</b>	<b>Always</b>	<b>Often</b>	<b>Sometimes</b>	<b>Rarely</b>	<b>Total</b>
<b>Pattern of use</b>					
<b>For an ultramarathon</b>	22 (18%)	24 (20%)	22 (18%)	6 (5%)	74 (61%)
<b>For a standard marathon</b>	18 (15%)	25 (20%)	25 (20%)	8 (7%)	76 (62%)
<b>For a half marathon</b>	15 (12%)	23 (19%)	34 (28%)	18 (15%)	90 (74%)
<b>Weekly, during normal training</b>	10 (8%)	12 (10%)	33 (27%)	27 (22%)	82 (67%)
<b>When injured</b>	27 (22%)	42 (34%)	35 (29%)	6 (5%)	110 (90%)
<b>Only when in pain</b>	21 (17%)	45 (37%)	35 (29%)	7 (6%)	108 (89%)
<b>Only when very tired</b>	6 (5%)	21 (17%)	30 (25%)	19 (16%)	76 (62%)
<b>When training and racing hard</b>	13 (11%)	26 (21%)	34 (28%)	15 (12%)	88 (72%)
<b>Depends on the day/ no regular pattern</b>	9 (7%)	9 (7%)	16 (13%)	12 (10%)	46 (38%)
<b>Type of heat</b>					
<b>Microwave hot pack</b>	12 (10%)	19 (16%)	29 (24%)	8 (7%)	68 (56%)
<b>Hot water bottle</b>	7 (6%)	15 (12%)	23 (19%)	12 (10%)	57 (47%)
<b>Hot water or bath</b>	19 (16%)	43 (35%)	25 (20%)	12 (10%)	99 (81%)
<b>Hot shower</b>	20 (16%)	47 (39%)	25 (20%)	6 (5%)	98 (80%)
<b>Jacuzzi</b>	1 (1%)	5 (4%)	5 (4%)	13 (11%)	24 (20%)
<b>Heat rub</b>	7 (6%)	21 (17%)	22 (18%)	10 (8%)	60 (50%)



**Table 3-30: Duration of heat therapy. Data are expressed as numbers (n) and percentages (%) of the total number of participants using heat (n = 122).**

<b>Heat (n = 122)</b>	
<b>Variable</b>	<b>Number and percentage of participants</b>
<b>1 to 5 minutes</b>	24 (20%)
<b>6 to 10 minutes</b>	40 (33%)
<b>11 to 15 minutes</b>	18 (15%)
<b>16 to 20 minutes</b>	24 (20%)
<b>21 to 25 minutes</b>	4 (3%)
<b>26 to 30 minutes</b>	7 (6%)
<b>More than 30 minutes</b>	5 (4%)

#### **I) Contrast therapy**

The pattern of use of contrast therapy is shown in Table 3-31. The use of contrast therapy as a recovery modality was reported by 91 participants, with contrast therapy being most commonly used for injuries (n = 88; 97%) and pain conditions (n = 86; 95%). The heat component was most commonly applied using a hot shower (n = 72; 79%), while the cold component was most commonly applied using ice or icepacks (n = 82; 90%). Almost two-thirds of participants (n = 58; 64%) start the contrast therapy with cold therapy, and more than half of participants end the contrast therapy with heat (n = 51; 56%) (Table 3-32). On average participants used contrast therapy once a day, and applied the cold therapy for an average of  $7.4 \pm 3.6$  minutes, and the heat for an average of  $7.1 \pm 3.5$  minutes. Contrast therapy was used for an average of  $2 \pm 1$  days.

**Table 3-31: Pattern of use of contrast therapy. Data are expressed as numbers (n) and percentages (%) of the total number of participants using contrast therapy (n = 91).**

<b>Contrast therapy ( n = 91)</b>					
<b>Variable</b>	<b>Always</b>	<b>Often</b>	<b>Sometimes</b>	<b>Rarely</b>	<b>Total</b>
<b>Pattern of use</b>					
<b>For an ultramarathon</b>	12 (13%)	18 (20%)	24 (26%)	4 (4%)	58 (64%)
<b>For a standard marathon</b>	7 (8%)	21 (23%)	29 (32%)	7 (8%)	64 (70%)
<b>For a half marathon</b>	4 (4%)	9 (10%)	27 (30%)	25 (27%)	65 (71%)
<b>Weekly, during normal training</b>	4 (4%)	11 (12%)	22 (24%)	21 (23%)	58 (64%)
<b>When injured</b>	33 (36%)	37 (41%)	14 (15%)	4 (4%)	88 (97%)
<b>Only when in pain</b>	18 (20%)	45 (49%)	18 (20%)	5 (5%)	86 (95%)
<b>Only when very tired</b>	0 (0%)	9 (10%)	26 (29%)	17 (19%)	52 (57%)
<b>When training and racing hard</b>	7 (8%)	21 (23%)	25 (27%)	10 (11%)	63 (69%)
<b>Depends on the day/ no regular pattern</b>	6 (7%)	12 (13%)	24 (26%)	11 (12%)	53 (58%)
<b>Method of application of heat</b>					
<b>Infra-red light</b>	0 (0%)	4 (4%)	16 (18%)	7 (8%)	27 (30%)
<b>Heat rub</b>	2 (2%)	19 (21%)	18 (20%)	7 (8%)	46 (51%)
<b>Heated towels</b>	0 (0%)	1 (1%)	4 (4%)	6 (7%)	11 (12%)
<b>Jacuzzi</b>	1 (1%)	2 (2%)	4 (4%)	13 (14%)	20 (22%)
<b>Hot shower</b>	11 (12%)	39 (43%)	19 (21%)	3 (3%)	72 (79%)
<b>Hot water or bath</b>	8 (9%)	29 (32%)	29 (32%)	5 (5%)	71 (78%)
<b>Hot water bottle</b>	1 (1%)	13 (14%)	16 (18%)	13 (14%)	43 (47%)
<b>Microwave hot packs</b>	1 (1%)	29 (21%)	22 (24%)	5 (5%)	57 (63%)
<b>Method of application of cryotherapy</b>					
<b>Ice gels</b>	4 (4%)	17 (19%)	15 (16%)	8 (9%)	44 (48%)
<b>Cold rub</b>	1 (1%)	9 (10%)	9 (10%)	11 (12%)	30 (33%)
<b>Swimming pool/sea</b>	4 (4%)	14 (15%)	31 (34%)	18 (20%)	67 (74%)
<b>Cold bath</b>	0 (0%)	8 (2%)	13 (14%)	11 (12%)	32 (25%)
<b>Cold shower</b>	1 (1%)	10 (11%)	19 (21%)	13 (14%)	43 (47%)
<b>Cold/ice water</b>	2 (2%)	14 (15%)	18 (20%)	12 (13%)	46 (51%)
<b>Ice/ice packs</b>	12 (13%)	44 (48%)	22 (24%)	4 (4%)	82 (90%)

**Table 3-32: Different patterns of application of contrast therapy. Data are presented as numbers (n) and percentages (%) of the total number of participants using contrast therapy (n = 91).**

<b>Variable</b>	<b>Modality starting the contrast therapy</b>	<b>Modality ending the contrast therapy</b>
<b>Cold</b>	58 (64%)	18 (20%)
<b>Heat</b>	13 (14%)	51 (56%)
<b>No regular pattern</b>	20 (22%)	22 (24%)

#### **3.3.4.2 Perceived mechanism of action of different recovery modalities**

Participants' perception of the mechanism of action of different recovery modalities are shown in Table 3-33. Of the participants using the respective modalities, over 70% positively identified the most appropriate mechanism of action for cryotherapy (88%) anti-inflammatory medication (85%), heat (73%) and protein (71%). In contrast, very few participants correctly identified the most appropriate mechanism of action of passive recovery (1%) and massage (19%). Between 10% and 19% of participants did not know the proposed mechanism of action for nine of the twelve different recovery modalities.

Table 3-33: Participants' perceptions of the mechanism of action of the different recovery modalities. Data are presented as numbers (n) and percentages (%) of participants using each modality respectively. Please note: the top three responses for the perceived mechanism of each modality are in bold, and the most appropriate mechanism of action of different modalities are underlined.

	Passive recovery (n = 388)	Active recovery (n = 327)	Stretching (n = 299)	Protein (n = 261)	Cryotherapy (n = 209)	Anti-inflammatory medication (n = 200)	Massages (n = 199)	Vitamins and minerals (n = 196)	Compression (n = 175)	Carbohydrates (n = 162)	Heat (n = 122)	Contrast therapy (n = 91)
Strengthens the body	105 (27%)	72 (22%)	75 (25%)	<u>113 (43%)</u>	3 (1%)	1 (1%)	6 (3%)	<u>69 (36%)</u>	2 (1%)	26 (16%)	0 (0%)	1 (1%)
Reduces swelling	16 (4%)	4 (1%)	4 (1%)	0 (0%)	<u>118 (57%)</u>	<u>73 (37%)</u>	12 (6%)	1 (1%)	<u>28 (16%)</u>	0 (0%)	4 (3%)	<u>12 (13%)</u>
Changes the flow of blood	<u>4 (1%)</u>	<u>31 (19%)</u>	17 (6%)	0 (0%)	<u>39 (17%)</u>	2 (1%)	<b>42 (22%)</b>	1 (1%)	<u>73 (42%)</u>	0 (0%)	<u>63 (52%)</u>	<u>41 (45%)</u>
Reduces pain	26 (7%)	17 (5%)	36 (12%)	1 (1%)	<u>28 (14%)</u>	<u>94 (48%)</u>	<u>38 (19%)</u>	1 (1%)	19 (11%)	0 (0%)	<u>26 (21%)</u>	<b>12 (13%)</b>
Speeds up energy restoration	<b>104 (27%)</b>	<u>42 (13%)</u>	10 (3%)	<u>81 (31%)</u>	3 (1%)	4 (2%)	14 (7%)	<u>55 (28%)</u>	4 (2%)	<u>93 (58%)</u>	4 (3%)	3 (3%)
Reduces lactic acid build up	17 (4%)	<u>96 (29%)</u>	<b>57 (19%)</b>	3 (1%)	6 (3%)	4 (2%)	<b>50 (26%)</b>	3 (2%)	21 (12%)	1 (1%)	0 (0%)	3 (3%)
I don't know	<b>67 (17%)</b>	45 (14%)	<b>57 (19%)</b>	<b>38 (15%)</b>	5 (2%)	<b>11 (6%)</b>	12 (6%)	<b>32 (16%)</b>	<b>23 (13%)</b>	<b>24 (15%)</b>	<b>17 (14%)</b>	9 (10%)
Other	49 (13%)	22 (7%)	43 (14%)	25 (10%)	8 (4%)	7 (4%)	21 (11%)	<b>32 (16%)</b>	5 (3%)	17 (11%)	7 (6%)	6 (7%)

Please note that stretching had no correct answer in the questionnaire and did not form part of the analyses for this part of the study.

#### **3.3.4.3 Factors influencing the choice of different recovery modalities**

The factors that influence participants' choice of different recovery modalities are summarised in Table 3-34. Personal experience was the main factor that influenced participants' use of all recovery modalities (from 24% to 54%), except contrast therapy. Information from fellow runners (from 12% to 29%) was the next common factor that influenced participants' choice of recovery modalities. While some participants reported that a health care provider (from 2% to 27%) or coach (from 2% to 15%) influenced their decision-making, the internet (from 4% to 12%), books (from 2% to 18%) magazines or advertisements (from 0% to 1%) had almost no influence on participants' choice of different recovery modalities.

#### **3.3.4.4 Perceived effectiveness of recovery modalities**

Participants' perception of effect of different recovery modalities are summarised in Table 3-35 on page 86. Participants using massage and passive recovery perceived these modalities to be highly effective, with 91% and 90% of participants reporting "good" to "excellent" effects for massage and passive recovery respectively. More than 80% of participants using active recovery, cryotherapy and stretching perceived these modalities to be highly effective. In contrast, more than 30% of participants perceived carbohydrates, vitamins and minerals, and compression to be minimally effective, with the effectiveness of these modalities rated as "fair", "poor" or "very poor".

Table 3-34: Factors influencing participants' use of different recovery modalities. Data are presented as numbers (n) and percentages (%) of participants using each modality respectively. Please note: the top three factors influencing choice of each modality are in bold.

Factors	Passive recovery (n = 388)	Active recovery (n = 327)	Stretching (n = 299)	Protein (n = 261)	Cryotherapy (n = 209)	Anti-inflammatory medication (n = 200)	Massages (n = 199)	Vitamins and minerals (n = 196)	Compression (n = 175)	Carbohydrates (n = 162)	Heat (n = 122)	Contrast therapy (n = 91)
Personal experience	211(54%)	157 (48%)	120 (40%)	80 (31%)	71 (34%)	104 (53%)	87 (45%)	93 (48%)	52 (30%)	67 (42%)	66 (55%)	22 (24%)
Health practitioner	7 (2%)	4 (1%)	53 (18%)	17 (7%)	48 (23%)	37 (19%)	35 (18%)	33 (17%)	16 (9%)	6 (3%)	22 (18%)	25 (27%)
Coach/trainer	41 (11%)	39 (12%)	44 (15%)	25 (10%)	11 (5%)	5 (3%)	16 (8%)	12 (6%)	10 (6%)	10 (6%)	2 (2%)	2 (2%)
Fellow runners	71 (18%)	75 (23%)	37 (12%)	52 (20%)	39 (19%)	34 (17%)	42 (22%)	26 (13%)	51 (29%)	31 (19%)	16 (13%)	18 (20%)
Books/magazine	27 (7%)	32 (10%)	19 (6%)	47 (18%)	24 (12%)	3 (2%)	3 (2%)	15 (8%)	19 (11%)	29 (18%)	8 (7%)	10 (11%)
Internet	15 (4%)	14 (4%)	12 (4%)	31 (12%)	9 (4%)	7 (4%)	5 (3%)	7 (4%)	16 (9%)	11 (7%)	4 (3%)	8 (9%)
Adverts	0 (0%)	0 (0%)	0 (0%)	3 (1%)	0 (0%)	1 (1%)	1 (1%)	1 (1%)	2 (1%)	2 (1%)	0 (0%)	0 (0%)
Other	16 (4%)	8 (2%)	14 (5%)	6 (2%)	5 (2%)	5 (3%)	6 (3%)	7 (4%)	9 (5%)	5 (3%)	3 (2%)	6 (7%)

**Table 3-35: Participants' perception of effectiveness of different recovery modality. Data are expressed as numbers (n) and percentages (%) of participants using each modality respectively.**

	Passive recovery (n = 388)	Active recovery (n = 327)	Stretching (n = 299)	Protein (n = 261)	Cryotherapy (n = 209)	Anti-inflammatory medication (n = 200)	Massages (n = 199)	Vitamins and minerals (n = 196)	Compression (n = 175)	Carbohydrates (n = 162)	Heat (n = 122)	Contrast therapy (n = 91)
<b>Excellent</b>	180 (46%)	89 (27%)	68 (26%)	106 (35%)	66 (32%)	49 (25%)	97 (50%)	50 (26%)	31 (18%)	28 (17%)	21 (17%)	14 (15%)
<b>Good</b>	170 (44%)	187 (57%)	138 (53%)	144 (48%)	108 (54%)	95 (48%)	80 (41%)	88 (45%)	91 (52%)	81 (50%)	64 (53%)	51 (56%)
<b>Fair</b>	35 (9%)	50 (15%)	53 (20%)	46 (15%)	31 (15%)	49 (25%)	18 (9%)	52 (27%)	41 (23%)	46 (29%)	33 (27%)	24 (26%)
<b>Poor</b>	3 (1%)	2 (1%)	2 (1%)	3 (1%)	2 (1%)	3 (2%)	0 (0%)	3 (2%)	7 (4%)	5 (3%)	3 (2%)	0 (0%)
<b>Very poor</b>	0 (0%)	1 (0.5%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	1 (1%)	5 (3%)	1 (1%)	0 (0%)	2 (2%)

### 3.3.5 Regression analyses of factors influencing the use of recovery modalities

Forward stepwise regression analyses were performed to determine whether there were any factors that may have influenced participants' use of different recovery modalities. The response (outcome) variable was the use of recovery modalities. The response variable was dichotomised into a yes/no response for the different recovery modalities included for regression analysis respectively. We selected to dichotomise the use of recovery modalities due to the large number of models being conducted, and in an attempt to clearly identify factors influencing the use of different recovery modalities. The coding of variables for the demographic and training models has been described in Table 3-2 (page 50). Significant factors influencing the use of different recovery modalities are shown in Table 3-36 (page 88). All significant factors in both the demographic and training models were associated with narrow 95% confidence intervals. The non-significant regression analyses are presented in Appendix H: Forward stepwise regression analyses. This study was unable to identify any predictive factors for the use of passive recovery and stretching. Males were almost twice as likely to use carbohydrates as a recovery modality, compared to females (Exp (B) = 1.7;  $p = 0.04$ ). Age was a significant predictive factor for the use of several recovery modalities. Participants older than 40 years were 50% to 60% less likely to use active recovery (Exp (B) = 0.5;  $p = 0.0001$ ) and compression (Exp (B) = 0.6;  $p = 0.03$ ) compared to younger participants respectively; but were twice as likely to use anti-inflammatory medication (Exp (B) = 2.0;  $p = 0.004$ ) compared to younger participants. Paradoxically, participants with higher monthly income were significantly less likely to use two of the more expensive recovery modalities namely protein (Exp (B) = 0.6;  $p = 0.049$ ) and massage (Exp (B) = 0.4;  $p = 0.002$ ).

Participants who were training more than 40 km.wk<sup>-1</sup> were almost twice as likely to use active recovery (Exp (B) = 1.9;  $p = 0.009$ ) and compression (Exp (B) = 1.7;  $p = 0.04$ ), compared to participants training less than 40 km.wk<sup>-1</sup>. Participants spending more than 50% of training time in road running were twice as likely to use vitamins and minerals (Exp (B) = 2.2;  $p = 0.003$ ), but 50% less likely to use compression (Exp (B) = 0.5;  $p = 0.008$ ), compared to participants spending less than 50% of training time in road running. Participants who had completed four or more standard marathons were also almost twice as likely to use vitamins and minerals (Exp (B) = 1.9;  $p = 0.006$ ), anti-inflammatory medication (Exp (B) = 1.8;  $p = 0.02$ ), and contrast therapy (Exp (B) = 1.8;  $p = 0.03$ ), compared to participants who were considered novice marathon runners, having completed three or less marathons. Participants who had a current injury were almost twice as likely to use compression (Exp (B) = 1.8;  $p = 0.04$ ) and heat (Exp (B) = 1.8;  $p = 0.04$ ), and almost three times as likely to use contrast therapy (Exp (B) = 2.7;  $p = 0.001$ ), and cryotherapy (Exp (B) = 3;  $p = 0.001$ ); compared to uninjured participants.



Table 3-36: Regression analyses of factors influencing the use of recovery modalities.

Model	Variables	Exp (B)	p	95% CI		Wald
				Lower	Upper	
Carbohydrates						
Demographic	Constant	0.5	0.0001**			14.9
	Gender	1.7	0.04*	1.0	2.8	4.1
Protein						
Demographic	Constant	1.9	0.0001**			20.1
	Monthly income	0.6	0.049*	0.4	1.0	3.9
Massage						
Demographic	Constant	1.2	0.32			1.0
	Monthly income	0.4	0.002**	0.3	0.7	9.7
Vitamins and minerals						
Training	Constant	0.4	0.0001**			16.1
	Running preference	2.2	0.003**	1.3	3.6	8.9
	Marathon frequency	1.9	0.006**	1.2	3.1	7.7
Anti-inflammatory medication						
Demographic	Constant	0.6	0.002**			9.3
	Age	2.0	0.004**	1.2	3.2	8.1
Training	Constant	0.8	0.02*			5.3
	Marathon frequency	1.8	0.02*	1.1	2.8	5.9
Active Recovery						
Demographic	Constant	5.7	0.009**			50.9
	Age	0.5	0.0001**	0.3	0.8	6.7
Training	Constant	1.9	0.002**			6.9
	Training distance	1.9	0.009**	1.2	3.3	9.4
Compression						
Demographic	Constant	1.0	0.79			0.1
	Age	0.6	0.03*	0.4	0.9	5.0
Training	Constant	0.7	0.23			1.4
	Training distance	1.7	0.04*	1.0	2.8	4.2
	Running preference	0.5	0.008**	0.3	0.8	7.1
	Current injury	1.8	0.04*	1.0	3.3	4.3
Cryotherapy						
Training	Constant	0.9	0.21			1.6
	Current injury	3.0	0.001**	1.6	5.6	11.4

\*\* p < 0.01; \* p < 0.05

**Table 3-39 continued: Regression analyses of factors influencing the use of recovery modalities.**

Model	Variables	Exp (B)	p	95% CI		Wald
				Lower	Upper	
Heat						
Training	Constant	0.4	0.0001**			74.4
	Current injury	1.8	0.04*	1.0	3.3	4.1
Contrast therapy						
Training	Constant	0.2	0.0001**			110.2
	Marathon frequency	1.8	0.03*	1.1	3.0	4.8
	Current injury	2.7	0.001**	1.5	5.0	10.5

\*\* p < 0.01; \* p < 0.05

### 3.3.6 Summary of results

The 433 participants in the study consisted of 64% males and 36% females, all well-educated, with 68% of participants earning more than R21 000 a month. There were significant differences between male and female participants in body mass, stature, BMI and monthly income. Participants were predominantly road runners. Although the mean weekly training distance of  $57.9 \pm 44.3$  km was twice as far as the minimum inclusion criterion for weekly training distance, participants had only completed an average of  $2 \pm 2$  standard marathons.

Passive recovery (90%), active recovery (76%) and stretching (67%) were the most commonly used recovery modalities. Participants used an average of  $6 \pm 2$  (range 1 to 12) recovery modalities, with some participants using one only and others all of the twelve modalities. All recovery modalities were used commonly for training and races while cryotherapy, anti-inflammatory medication, contrast therapy, heat and massage were more frequently used for injuries and pain conditions.

Of the participants using the respective modalities, over 70% positively identified the most appropriate mechanism of action for cryotherapy (88%), anti-inflammatory medication (85%), heat (73%) and protein (71%). In contrast, very few participants correctly identified the mechanism of action of passive recovery (1%) and massage (19%). Between 10% and 19% of participants did not know the proposed mechanism of action for nine of the twelve different recovery modalities. Personal experience and information from fellow runners were the two main factors that influenced the choice of different recovery modalities.

Participants using massage, active recovery, passive recovery, cryotherapy and stretching generally perceived these modalities to be highly effective. In contrast, more than 30% of participants perceived carbohydrates, vitamins and minerals, and compression to be minimally effective.

The demographic factors such as gender, age, level of education and monthly income were predictive of the use of carbohydrates, protein, massage, anti-inflammatory medication, active recovery and compression. Training factors associated with more experience (for example, number of marathon) were predictive of the use of vitamins and minerals, anti-inflammatory medication, active recovery and compression. The presence of a current injury was predictive of the use of anti-inflammatory medication, cryotherapy, heat, and contrast therapy. The results will be discussed in more detail in Section 3.4.

## **3.4 DISCUSSION**

The purpose of this study was to identify the prevalence and pattern of use of recovery modalities by endurance runners. The findings will be discussed in a similar order as the presentation of results in Section 3.3.

### **3.4.1 Participants**

#### **3.4.1.1 *Sample size and research methodology***

Data from 433 respondents were included for analysis in this study. This was well in excess of the 276 participants that were required for a statistical power of 95%. This study used a web-based survey tool, FluidSurvey©. The use of FluidSurvey© supported multiple browsers or platforms; prevented multiple submissions from individual respondents; enabled the questionnaire to be adapted according to the individual respondent's selection of recovery modalities; allowed respondents to save their response multiple times before submission; and automatically provided the respondents with feedback on completion of the questionnaire. This use of a web-based survey tool is advantageous as it allows for rapid distribution of the questionnaire at a low cost. However, it is disadvantageous in that there is no direct communication with prospective respondents. In this study, permission was obtained for the study information and survey link to be distributed to potential respondents by running clubs. The principal researcher only made direct email contact with potential respondents who provided their email addresses at races. However, it is possible that potential respondents may have viewed the invitation to complete the survey as an unsolicited request that infringed on their privacy. This may have negatively influenced response rates<sup>127</sup>.

Due to the study design and recruitment strategy, it is impossible to calculate a response rate for the study. A 2009 Cochrane review<sup>128</sup> identified several factors that improve the response rate to electronic surveys. The main factor that may have negatively affected the response rate in this study was the length of the questionnaire.

It is recognised that future studies should target specific recovery modalities, with the aim of keeping questionnaires short. In addition, although participants were provided with an information sheet on completion of the questionnaire, the use of non-monetary incentives (for example, a magazine subscription) may also improve response rates.

However, of the 649 questionnaires returned, 190 questionnaires were excluded due to incomplete responses. This represents a 29% attrition rate, which is fairly high for a study of this nature. Although the use of an online survey tool allowed the principal researcher to reach a wide population in a cost-effective and efficient way, the issue of attrition and potential for attrition bias are significant concerns. A high attrition rate may suggest potential problems in the design of the survey, but does not necessarily indicate the presence of attrition bias. Due to the descriptive nature of this study, it was necessary to include a wide range of recovery modalities in the questionnaire. The length of the questionnaire may therefore have contributed to the relatively high attrition rate in this study<sup>129</sup>.

#### **3.4.1.2 Descriptive characteristics**

In this study, 75% of participants were very well educated, having a University or College education, and more than two thirds of participants earned R21 000 or more a month. This might be due to the recruitment strategies limiting the participants to households with email and internet access. Other than passive recovery and some forms of active recovery, all other recovery modalities require some economic investment. Therefore, runners from more disadvantaged backgrounds might use different modalities and display different pattern of use than the participants of this study. Further research should explore the use of recovery modalities by runners from more disadvantages backgrounds.

There were only two significant differences between male and female participants (Section 3.3.2 and Table 3-3; page 53). The first was that males earned a significantly higher monthly income than females. This was expected as the 2011 South African Census Report stated that males earn up to three-quarters of household incomes in the average middleclass households<sup>130</sup>. The second difference was a significant difference in their physique, i.e. height, weight and body mass index. The males, as expected, were heavier, taller, and had a higher body mass index than the females. The males' BMI at 24.4 was higher than expected, as an average BMI for endurance runners is considered to be close to 21<sup>4</sup>.

#### **3.4.1.3 Training history**

In this study, the average weekly training distance ( $58 \pm 44$  km) of participants was almost double the minimum inclusion criterion of  $30 \text{ km}\cdot\text{wk}^{-1}$  (Table 3-5; page 55); however the mean number of standard marathons completed was a low  $2 \pm 2$ . Grant et al.<sup>131</sup> classified any runner who had completed less than three marathons as a novice runner<sup>131</sup>. Therefore, according to this definition the participants in this study were mainly novice body<sup>3</sup>.

The majority of participants ( $n = 345$ ; 80%) spend 50% or more of their training time on road running (Table 3-7; page 56). This could be due to the recruitment of participants at marathons where there are more road runners. Although this researcher recruited participants at two trail races, the numbers of participants at these races were far lower than for marathons. However, 340 participants (79%) reported that they spent some training time on trail running (Table 3-7; page 56). The questionnaire failed to include any specific trail running training or race questions. Thus, there were no questions about the number, the gradient or distance of trail races or any questions about specific trail running training. This study's results therefore could be considered to have a bias towards road runners.

#### **3.4.2 Recovery modalities**

In this study, participants used a mean of  $6 \pm 2$  recovery modalities. There were also no significant differences in the use of different recovery modalities between male and female participants (Table 3-8; page 58). This researcher was unable to find any previous studies that have reported the number of recovery modalities used by endurance runners or athletes in general. The fact that most runners were classified as novice runners might possibly have impacted on the use of different modalities. It is possible that as the participants were unaccustomed to distance training and racing they still might be experimenting with recovery modalities, potentially contributing to the high average number of modalities used in this study. This finding emphasises the need for high quality research to establish an effective recovery protocol to guide experienced and novice runners, and prevent unsafe use of different recovery modalities.

This study showed that passive recovery was used most frequently, particularly when runners were tired. There is no research to support the wide use of passive recovery. Although passive recovery might be easy and does not have an economic impact, runners must be educated that complete rest may not accelerate recovery after training and competition. Active recovery and stretching were also used by a large number of participants. Although most participants used active recovery according to what the limited available literature prescribes<sup>2</sup>, better quality research is necessary to investigate ideal dosage to enhance recovery. There is a lack of research to support the use of stretching as part of the recovery protocol, at present the available research focussed on injury prevention rather than recovery<sup>24</sup>.

It was found that certain recovery modalities (cryotherapy, heat, contrast therapy and compression) were used more frequently when runners were injured. This can be seen as a good practice as research has shown that these modalities might be effective in enhancing recovery following injuries<sup>3,13,20–22</sup>.

#### **3.4.2.1 Pattern of use**

##### **a) Passive recovery**

Passive recovery was widely used by almost all of the participants. This was not surprising as rest is a very natural need and the default option when the body is fatigued<sup>2,5</sup>. Table 3-10 (page 60) indicates that participants used passive recovery more frequently after exhausting activities such as an ultramarathon, when participants had trained hard, or when they are tired; than for less exhausting activities, such as a half marathon or during normal training. Participants reported more rest days after more exhausting activities, such as an ultramarathon than after a half marathon or just a normal training week (Table 3-11; page 60). Resting days and adequate recovery are crucial when training very hard for a specific time or during increased volume or intensity, to avoid fatigue and reduced exercise performance<sup>31,50,72,73</sup>. Unfortunately, there is no clear protocol or recommendation in the literature as to what the most advantageous rest period is after a specific event.

A high number of participants reported the use of passive recovery after injury, although it is concerning that a total of 356 participants (82%) reported that they use passive recovery techniques only once injured.

Only seventeen participants reported that being injured was not applicable to them, suggesting that the other 60 participants continue running with their injuries, or had injuries that did not limit their training. Unfortunately this study's questionnaire did not provide a sufficiently clear answer to these questions.

Very few participants reported that they rarely use passive recovery, even after an ultramarathon (n= 5; 1%) or standard marathon (n = 12; 3%). All of these participants reported that they often or always use active recovery. This is a good practice as active recovery has been shown to have a better effect on the normalisation of blood lactate concentrations during recovery than passive recovery<sup>2,20,22,95</sup>.

##### **b) Active recovery**

A high proportion of the participants (n = 327; 78%) used active recovery. Since active recovery has been shown in Level Two evidence studies to be more effective than passive recovery<sup>2,20,22,95</sup>, runners should be educated to rather use active than passive recovery. Many runners reported that they run or walk for active recovery (Table 3-12; page 61). This is a good practice, as current literature recommends using the same muscle groups during active recovery as those used in the initial activity<sup>2,20</sup>.

Although most runners exercise about once a day for two days and about half an hour to an hour at a time to recover (Table 3-13; page 62) there is no evidence or specific recommendations on the most effective duration or timing of active recovery.

### **c) Stretching**

Although many participants (n = 299; 87%) in this study indicated that they use stretching for recovery, there is no quality research to support this practice<sup>24</sup>. One Cochrane review of ten small studies that looked at the effect of stretching before or after physical activity on muscle soreness found very consistent findings. They showed there was minimal or no effect on the muscle soreness experienced between half a day and three days after the physical activity<sup>96</sup>. According to this review stretching might not have a place during the recovery process.

Most participants reported that they stretch all the large muscles in their legs, as well as their groin, back and buttocks (Table 3-14; page 63). Eighty percent of these participants indicated using stretching before training, and 69% of participants stretched before running a half marathon. There is, however, conflicting evidence and only poor quality published research about stretching before an activity. Two systematic reviews of the literature have recommended avoiding prolonged stretching in the pre-exercise period<sup>32</sup>, or to be very careful when stretching before exercise to avoid overstretching<sup>24</sup> (Section 2.6.1.3; page 17). Almost one third of participants reported that they hold each stretch for about 30 seconds (Table 3-15; page 64), which is prescribed in the literature. Brukner and Khan<sup>13</sup> recommend to stretch gently for 30 to 60 seconds without any feeling of discomfort or pain<sup>13</sup>. Better quality research followed by runner education is necessary to establish the best stretching protocol to aid recovery, as this study has demonstrated that endurance runners use this practice regularly.

### **d) Protein**

Sixty percent of participants (n = 261) reported using protein as a recovery modality. This is a larger number than the participants (n = 162; 37%) who reported using carbohydrates to facilitate recovery (Table 3-8; page 58). It is interesting to speculate on the influence of recent popular media reports in South Africa about the benefits of high fat/protein/low carbohydrate diet<sup>132</sup> on these numbers specifically. It is possible that these figures might reflect a paradigm shift from carbohydrate loading to high fat and protein diets. However, this study did not examine participants' regular dietary habits and eating practices. It is therefore impossible to determine whether participants are just consuming extra protein specifically to enhance recovery from training and competition, or whether they changed their normal diet to a high protein diet. Although this theory is speculative, 47 (18%) participants reported that their use of protein as a recovery modality was predominantly influenced by books or magazines (Table 3-34; page 85).

Perhaps one of the key findings of this study is that participants' use of recovery modalities is largely influenced by fellow runners or popular media. This highlights the need for both translational research and the dissemination of research findings, to ensure that athletes adopt practices that are based on the best available evidence.

Although almost all (97%) the participants consumed protein after training, and 87% after training hard, only 28% and 24% of participants reported "always" using protein after training and training hard respectively, meaning that it was not an established habit for most of the participants. The same patterns for protein consumption were observed after races (Table 3-16; page 65). Protein has been shown to increase muscle mass, assist in recovery and boost the immune system after exercise<sup>112,113</sup>. These beneficial effects need to be promoted among athletes.

The ACSM recommends that an athlete consumes protein within 30 minutes after training or races to enhance muscle repair<sup>4</sup>. The ISSN also recommends that an athlete take extra protein after exercise in combination with additional carbohydrates<sup>33</sup>. Only 26% of participants reported that they used protein within the first 30 minutes after a race (Table 3-17; page 66). Further education will therefore be beneficial to the running community.

#### **e) Cryotherapy**

In this study, less than half the participants reported using cryotherapy as a recovery modality. The literature recommends that cryotherapy should be mainly used when a participant is injured or in pain (Table 3-18; page 67)<sup>3,13,21,22,28</sup>. Cryotherapy causes significant changes in the systemic, hormonal and inflammatory markers<sup>3,13,21,22,28</sup>. It can significantly decrease the pro-inflammatory mediator interleukin-1 $\beta$  as well as the anti-inflammatory mediator interleukin-1 $\alpha$ . Therefore, there is the possibility that cryotherapy may decrease muscle adaptation and thus the training effects on the muscle after training as a result of these effects on the inflammatory cytokines. It may be wiser to use cryotherapy only after traumatic injuries<sup>28</sup>. Participants reported a wide range of application time for the cryotherapy (Table 3-19; 68-67). Most participants applied it for about ten, fifteen or twenty minutes. There were no clear instructions in the literature for the optimal cryotherapy duration as studies reported application from three<sup>5,52</sup> to 24<sup>2,19,52,120</sup> minutes. Unfortunately, it will be difficult to establish a clear protocol for the most effective time to apply cryotherapy, as the BMI and obesity of the participants, the depth of the tissue that requires the cryotherapy, the temperature of the cold water or ice and the temperature of the skin all need consideration<sup>19</sup>.



#### **f) Anti-inflammatory medication**

Almost half of the participants (n = 200) used anti-inflammatory medication as a recovery modality. This wide reported use of anti-inflammatory medication is a significant concern. Although almost all of the participants that use anti-inflammatory medication reported that they use NSAIDs when they are in pain or injured, 75% reported using them after training, and 83% used them, when they felt tired during races (Table 3-20; page 69). Three participants even reported that they use anti-inflammatory medication every hour during a race (Table 3-21; page 70). There is no research to support this pattern of use but the literature notes all the harmful side effects of regular use such as gastrointestinal problems, dehydration, and liver and kidney dysfunction. NSAIDs also has an adverse effect on the initial tissue healing phase<sup>23,99–104</sup>. The literature recommends the use of paracetamol in the first 48 hours after injury rather than anti-inflammatory medication<sup>100,103</sup>. The high use of anti-inflammatory medication before, after and during races is a significant concern that should be addressed.

#### **g) Massage**

In this study, 199 (49%) of participants indicated using massage for recovery. Participants reported using massage to assist with recovery from injuries, pain or hard training or racing. Only three participants reported that they always used massage as part of their normal weekly training schedule (Table 3-22; page 71). Massage has been proven to have an effect on blood pressure, although there is no significant effect on the metabolism of creatine kinase compared to active or passive recovery<sup>25,26</sup>. Although massage has a psychological effect by increasing a feeling of well-being, decreasing stress and lowering the perceived perception of muscle pain<sup>20,95,107</sup>, there is no good research that supports the use of massage as part of the recovery process. Almost two-thirds of participants used sports massage therapists or physiotherapists for their massage. An interesting observation is that 16% of participants went for lymotherapy, a treatment focusing on the fascia lines of the body. Although lymotherapy was developed in the late 1990's, it has only recently become a popular form of massage therapy in South Africa in the last few years<sup>133</sup>. This might indicate that lymotherapy had a good publicity campaign and possibly the influence of peer pressure on runners. It might also indicate that runners are still searching for better recovery modalities.

#### **h) Vitamins and minerals**

One hundred and ninety-six participants (45%) reported the use of extra vitamin and mineral supplements during training or racing, with a high prevalence for weekly use during regular training (Table 3-24; page 73). There is no literature to support the use of vitamins or minerals specifically as a recovery modality. It would be interesting to know exactly what influence advertising campaigns have on the use of vitamins and minerals. Some vitamins for example vitamins A and E, have a beneficial effect on reducing muscle damage<sup>16</sup> while vitamin D influences regulation of anti-inflammatory cytokine production<sup>116,117</sup>.

Vitamin C deficiency has been proven to increase fatigue and decrease energy<sup>16</sup>. Magnesium has been shown to influence glycogen, fat and protein metabolism<sup>16</sup>. Most participants reported the use of multivitamins, vitamin C and magnesium to support the above-mentioned benefits. However, research recommends that athletes consuming a well-balanced diet that includes a variety of different food groups do not need to include vitamin and mineral supplements<sup>16</sup>.

#### **i) Compression**

In this study, 175 (40%) participants reported using compression garments as a recovery modality, despite the current lack of evidence for compression garments in aiding recovery. Sperlich et. al.<sup>29</sup> reported that compression shorts made no difference compared to normal shorts in the muscle blood flow or glucose uptake after high intensity exercise<sup>29</sup>. Although available literature suggests that the compression garments must be worn immediately after strenuous or prolonged activity for optimal effect<sup>20,108</sup>, participants reported the use of compression during training or races rather than afterwards (Table 3-25; page 74). Two-thirds of participants reported the use of compression when injured or in pain.

Although it was beyond the scope of this study to establish the type of injury or pain for which the participants used the compression, it is well-known that compression used as part of the RICE<sup>13</sup> regime after an acute injury is beneficial to reduce swelling. Although there is no clear protocol to recommend the duration of compression, Estell 2011<sup>20</sup> found less pain and oedema in runners' calves and quadriceps muscles when gradual compression sock was used for 72 hours after running an ultramarathon than in runners wearing placebo socks. In this study almost a third of participants used compression for less than two hours while another third kept the compression on for between two and twelve hours after a race. Only two participants used compression for more than 36 hours (Table 3-26; page 75). It is thus clear that runners do not use compression garments following the best available protocol. More research is needed to guide the use of compression as a recovery modality.

#### **j) Carbohydrates**

Only 162 (32%) participants used carbohydrates as a recovery modality for training and races. Glycogen is the primary fuel source for sub-maximal exercise such as endurance exercise<sup>6,33</sup>. All endurance runners should be consuming carbohydrates to maintain their blood glucose levels during exercise and to replenish the glycogen stores after prolonged exercise<sup>19,33</sup>. Although a high number of participants who used carbohydrates reported that they consumed extra carbohydrates before, during and after races and training, there were fewer participants who reported to "always" consumed carbohydrates after a half-, full- or ultramarathon than during races (Table 3-27; page 77). Research has shown that glycogen synthesis is at its highest when carbohydrates are consumed directly after exercise<sup>33</sup>. Table 3-28 (page 78) showed that less than a third of participants consumed carbohydrates within the first half hour.

The use of carbohydrates should be promoted as it has been proven as a successful recovery modality. Recently, research has suggested that the traditional carbohydrate loading regime is unnecessary, and that one to one and a half days of high carbohydrate use is adequate prior to competition to ensure sufficient glycogen stores<sup>14,19</sup>. More than two thirds of participants reported that they “carbo-loaded” before a race (Table 3-28; page 78), participants “carbo-loaded” for an average of  $3 \pm 3$  days. This correlates with the latest recommendations that a low-carbohydrate diet is unnecessary and that three days of high-carbohydrate intake prior to competition is sufficient to ensure adequate glycogen stores<sup>14,33</sup>.

#### **k) Heat**

Just more than a quarter of participants ( $n = 122$ ; 28%) used heat as a recovery modality although there is scant evidence to support this. Most of these participants reported that they used heat when in pain or when injured (Table 3-29; page 79). As discussed in section i) on page 94 the study’s results do not indicate for what type of injury or pain heat therapy is used. As heat causes vasodilatation, a reduction in the perceived perception of pain and a feeling of well-being may be beneficial in the recovery process as long as it is avoided in the first 48 hours after an acute injury<sup>21,32</sup>.

#### **l) Contrast therapy**

A low number of 91 (18%) participants reported use of contrast therapy as a recovery modality. Contrast therapy was predominantly used where participants reported pain or an injury (Table 3-31; page 81). There is poor quality Level Two or lower level evidence available, so the effectiveness of contrast therapy as a recovery modality has not been fully established. There are vague guidelines on the best dosage of contrast therapy and it seems that each study used a different protocol for the application of contrast therapy. Although research suggests that it may be beneficial to end the contrast therapy with cryotherapy<sup>19,32</sup>, only 20% of participants finished-off their session with cryotherapy. Most started with cryotherapy and ended with heat (Table 3-32; page 82). The mean application time for the cryotherapy was  $7.4 \pm 3.6$  minutes which is long time when compared to most studies that used an application period of one minute only<sup>19,32</sup>. The mean heat application was  $7.1 \pm 3.5$  minutes which is also very long as compared to the one to three minutes of heat used in research studies<sup>19,32</sup>. Better quality research is necessary to establish if contrast therapy should be used as a recovery modality, as well as the optimal mode of application of contrast therapy.

#### **3.4.2.2 *Perceived mechanism of action of different recovery modalities***

One objective of this survey was to evaluate the knowledge and understanding participants have with regard to the recovery modalities that they use. Most participants indicated that they know the main mechanism of cryotherapy, anti-inflammatory medication, heat and protein (Table 3-33; page 83) and an average number of participants knew the mechanism of the other recovery modalities. Participants had the least knowledge of passive recovery, which was the recovery modality that was used most frequently (Table 3-8; page 58). Most participants indicated that passive recovery strengthens the body or speeds up energy restoration. Both of these answers could be correct, but according to the literature, passive recovery slows down the heart and metabolic rate, and thereby changing the blood flow, an option only four participants (1%) chose. For all recovery modalities excluding cryotherapy, anti-inflammatory medication and massage, between 10 and 19 percent of participants reported that they do not know the mechanism of effects of the modality they usually use. This causes a possible safety issue. A further safety issue is the fact that participants reported to use an average of 6 recovery modalities. Currently there is inadequate research done on the interaction of different recovery modalities, and potential positive or negative effects associated with any interactions. This is a major area of education that urgently needs attention.

#### **3.4.2.3 *Factors influencing the choice of different recovery modalities***

Participants reported that personal experience was the most influential factor in deciding which recovery modality to use, except for contrast therapy (Table 3-34; page 85). The second most influential factor reported was advice from fellow runners. It is possible that sources of information might have a significant impact on runners' lack of knowledge regarding the mechanism of action of different recovery modalities. Health practitioners and coaches, who may be a better source of knowledge, have very little influence on runners' choice of different recovery modalities. Similarly, advertisements and the internet were also not strong influences for runners' choice of recovery modalities. If personal experience and fellow participants are the two main influences in runners' decision-making, more traditional educational methods might not be the most effective way of teaching runners about recovery guidelines. If runners influence fellow runners, then education and change must start within the running community. Peer-led education has often been implemented in the communities with great success to improve the knowledge, behaviour and attitude towards a medical condition<sup>134-136</sup>. To create a community of change in a group that mostly influences themselves, peer-led education may possibly be the only effective way to foster a change. According to Kotler and Zaltman<sup>137</sup> social media can be an effective peer-led tool to change and educate a community, although there are multiple obstacles<sup>137</sup> which are beyond the scope of this thesis. There are multiple runners' blogs and forums on the internet.

Although few runners reported that the internet influenced their decision to use a particular recovery modality, the questionnaire was not sufficiently specific in specifying the various types of internet media such as Google, blogs, forums, social networks etc. Internet-based social networking, blogs and forums may be the easiest way to start educating runners to ensure the safer and more effective use of recovery modalities. Further studies are needed to confirm whether peer-led online educational interventions are effective for runners.

#### **3.4.2.4 *Perceived effectiveness of recovery modalities***

According to the perceived effectiveness that the participants reported passive recovery, massage, active recovery, cryotherapy and stretching are effective while compression, carbohydrates, vitamins and minerals and are less effective (Table 3-35; 84). This study showed that runners still used these recovery modalities although the perceived effectiveness of the recovery modalities was reported as low. It is possible that the fear of stopping the use of a recovery modality have an influence on the choice and behavior of runners. The questionnaire has not explored this option, but further research might have to address the issue. Peer pressure might have an influence, as advice from fellow runners was reported as a major resource that influenced runners' choice of recovery modalities. It is possible that runners used too many recovery modalities to enable any one of the recovery modalities to be effective on its own. There is a lack of evidence for the potential positive or negative effects associated with any interactions between different recovery modalities. No significant association between the number of recovery modalities used and the perceived effectiveness of the modalities was found (Table 13-13; Appendix H: Forward stepwise regression analyses).

#### **3.4.3 *Factors influencing the use of recovery modalities***

There were a few interesting factors influencing the use of recovery modalities. The demographic model, as discussed in Section 3.2.5 (page 49), may predict the use of a few recovery modalities. All demographic variables with the exception of education had an influence on the use of some recovery modalities. The runners older than 40 years use anti-inflammatory medication more for recovery. As older athletes might have more injuries it might make sense that older runners will want to use anti-inflammatory medication more often. As they heal slower and might have more medical conditions than a younger runner<sup>13</sup> it is crucial to educate them regarding the negative side effects of anti-inflammatory medication<sup>23</sup>.

Interestingly, in the training model the participants that ran three or more marathons seemed to use anti-inflammatory medication, compression, vitamins and minerals almost twice as frequently as novice runners, who completed less than three marathons<sup>131</sup>. Fellow runners as discussed in Section 3.4.2.3 (page 96), may be responsible for the trend seen in this research, as novice runners may not yet have been exposed to as many fellow runners who recommended the use of anti-inflammatory medication, compression, vitamin or minerals. Current injuries, as can be expected, have an influence on the RICE regime<sup>13</sup> modalities. Cryotherapy and compression are three times as likely to be used by participants who reported that they have a current injury that affects their training programme. This is a good finding, although cryotherapy, compression and passive recovery has not been proven as effective recovery modalities, there is good research to support their use after acute injuries<sup>3,13</sup>.

#### **3.4.4 Limitations of the study**

Due to the descriptive nature of the study the results are derived from a self-reported, researcher-compiled questionnaire. Although the questionnaire was validated and piloted, the results can only describe this specific population's use of recovery modalities and no generalisation can be made for the general population. It is recognized that the research design might therefore introduce inherit bias to the study results. The length of the questionnaire used in this study allowed more in depth data gathering to gain a better understanding about the use of recovery modalities, but took time and patience to complete. Therefore the length of the questionnaire was a major limitation. The type of person that takes the time to complete a time-consuming questionnaire may have a different attitude and knowledge about recovery modalities than a person who decides not to complete the questionnaire. With respondents mainly completing the electronic version of the questionnaire rather than the hard copy (Figure 3-1; page 52), the participants represent a population with access to the internet and email. Although the hardcopy was available at the races where recruitment was done, only five runners agreed to complete it after finishing the race, as most runners were tired and the questionnaire would have taken too long to complete to their liking.

This is clearly visible by studying the demographic details of the participants in Table 3-3 (page 53) and Table 3-4 (page 53). A high number of participants (n = 310; 72%) were well-educated in a college or university, while 206 participants (48%) earned more than R30 000 a month. This study's participants therefore represent endurance runners from the middle and upper socio-economic classes. The study's outcome is limited only to English-literate communities.

Finally, due to the large number of different regression models, we acknowledge the possibility of type 1 error in these results. However, type 1 error will be minimised due to the large sample size included for analysis.

#### **3.4.5 Summary and recommendations**

This is the first study, according to the knowledge of this researcher that describes the self-reported use of recovery modalities by endurance runners. Further studies are necessary to help establish guidelines for each modality as there are well researched guidelines for carbohydrates and protein only. Further studies are needed to explore the knowledge, attitude and perceptions in more depth, especially in the lower socio-economic endurance runner. It may also be useful to explore the use of recovery modalities by trail runners as well as by elite endurance runners to see if there is a different pattern of use and efficiency level in the different populations. Other limitations in the literature are the effectiveness and interaction of combining two or more recovery modalities. Monedero<sup>95</sup> found that a combination of active recovery and massage had a better combined effect than the two single modalities. The potential benefit of combining different recovery modalities needs further research as this study found that participants used a combination of a mean of six recovery modalities.

## 4 CHAPTER FOUR: SUMMARY AND CONCLUSION

Endurance running is unique as it causes fatigue, DOMS exercise-induced muscle damage and exhaustion in both recreational and elite athletes<sup>7,8,31,37</sup>. An effective recovery strategy may allow runners to return to training and competition more quickly. Recovery is essentially a passive process; however there are numerous commercially available recovery modalities that may enhance the recovery process<sup>5,6,16,17,20,21,93,100,113</sup>. There is equivocal and often conflicting evidence for many recovery modalities; however, anecdotally, the use of recovery modalities seems to be common practice among endurance runners.

Therefore, the overall aim of this study was to determine the use of recovery modalities by endurance runners. Based on the evidence provided in this dissertation, the study objectives as described in Section 1.2.2 (page 2) may be answered as follows:

- *To obtain information on recovery modalities used by endurance runners such as the type of modalities, frequency of use, and use during training and races.*

This study demonstrated widespread self-reported use of different recovery modalities, despite the lack of evidence for efficacy of most of the modalities in enhancing or accelerating recovery following endurance running. Passive and active recovery and stretching were used most frequently. All recovery modalities were used mainly during training and races although a variable pattern of use was reported. Table 4-1 provides a concise summary of the reported pattern of use of different modalities compared to current evidence-based guidelines for use, and suggests recommendations for current practice and future research.



**Table 4-1: Summary of the reported pattern of use of recovery modalities in this study compared to current evidence-based guideline, and recommendations for current practice and future research.**

<b>Recovery modality</b>	<b>Reported pattern of use in this study</b>	<b>Evidence-based guidelines</b>	<b>Recommendations</b>
<b>Passive recovery</b>	<p><b>When:</b> Most scenarios especially for exhausting activities and injuries.</p> <p><b>Dosage:</b> 1 day during training, 3 days after marathons and 5 days after ultramarathons.</p>	<p><b>When:</b> No specific recommendations, but it might be less efficient than active recovery and cryotherapy<sup>5,20,21</sup>.</p> <p><b>Dosage:</b> No literature available.</p>	With no research to support the wide use of passive recovery, education is necessary to inform athletes that complete rest may not accelerate recovery after training and competition.
<b>Active recovery</b>	<p><b>Type:</b> Running or walking.</p> <p><b>Dosage:</b> 1 to 2 days, 30 to 60 minutes.</p>	<p><b>Type:</b> Use same muscle groups that were used in the activity you like to recover from<sup>2,20</sup>.</p> <p><b>Dosage:</b> No literature available.</p>	<p>Participants are using active recovery according to what the available literature prescribes.</p> <p>Better quality research is necessary to investigate ideal dosage to enhance recovery</p>
<b>Stretching</b>	<p><b>When:</b> Before and after training and races. When injured or in pain.</p> <p><b>Type:</b> All the muscle groups in the legs, back, buttocks and groin.</p> <p><b>Dosage:</b> 10 to 30 seconds.</p>	<p><b>When:</b> Possible that stretching has no recovery benefit<sup>96</sup>. Avoid pre-exercise warm up period to prevent over stretching<sup>24,32</sup>.</p> <p><b>Type:</b> No specifications in the literature. But be careful not to over stretch.</p> <p><b>Dosage:</b> Gentle stretch for 30 to 60 seconds.</p>	<p>Education is critical to teach runners that stretching has no recovery benefit.</p> <p>More research might help to confirm the new findings that stretching must be avoided in the pre-exercise warm-up period.</p>
<b>Protein</b>	<p><b>When:</b> After training and races. Few participants reported use within 30 minutes after completion of training or racing.</p> <p><b>Type:</b> Eggs, normal meal and milk.</p>	<p><b>When:</b> Within 30 minutes after completion of training or racing<sup>4</sup>. Use in combination with carbohydrates for optimal effect<sup>3</sup>.</p> <p><b>Dosage:</b> 1.2 g kg<sup>-1</sup> day<sup>-1</sup> of protein for endurance athletes<sup>33,113</sup>.</p>	Many participants are already using protein; however education can optimise this recovery strategy by emphasising the benefit of consuming protein as soon as possible after exercise.

**Table 4-1 continue: Summary of the reported pattern of use of recovery modalities in this study compared to current evidence-based guideline, and recommendations for current practice and future research.**

<b>Recovery modality</b>	<b>Reported pattern of use in this study.</b>	<b>Evidence-based guidelines</b>	<b>Recommendations</b>
<b>Cryotherapy</b>	<b>When:</b> During pain and injury. <b>Dosage:</b> Wide variety of 10 to 20 minutes.	<b>When:</b> Only after traumatic injury <sup>28</sup> . <b>Dosage:</b> No specific proven dosage as BMI and type of injured structure will influence the application <sup>19</sup> .	Most participants used cryotherapy correctly according to current available evidence. Better quality research will help to establish a protocol to use cryotherapy as recovery modality.
<b>Anti-inflammatory medication</b>	<b>When:</b> During and after training or races; or when tired, injured or in pain.	<b>When:</b> Never use anti-inflammatory medication as a recovery modality. Rather use paracetamol before, during, or in the first 48 hours after exercise or a race <sup>100,103</sup> .	Education is crucial as anti-inflammatory medication is widely used during exercise when paracetamol is a safer choice.
<b>Massage</b>	<b>When:</b> Injured, in pain or when training or racing hard. <b>Type:</b> Physiotherapist or sports massage therapist. <b>Dosage:</b> 30, 45 or 60 minutes.	<b>When:</b> No evidence that it is effective as a recovery modality <sup>80</sup> .	Further research is needed to establish if massage can be advocated as a recovery modality.
<b>Vitamins and minerals</b>	<b>When:</b> Weekly during normal training or when training or racing hard. <b>Type:</b> Mainly multivitamins, magnesium and vitamin C.	<b>When, dosage and type:</b> No clear recommendations for recovery process. But recommended that supplementation is unnecessary during a well-balanced diet that includes a variety of food groups <sup>16</sup> .	Research specifically aimed the effects of dietary interventions on the recovery process might help for clear guidelines. Education about a well-balanced diet might be necessary although detailed dietary information did not form part of this study's objectives.

**Table 4-1 continue: Summary of the reported pattern of use of recovery modalities in this study compared to current evidence-based guideline, and recommendations for current practice and future research.**

<b>Recovery modality</b>	<b>Reported pattern of use in this study.</b>	<b>Evidence-based guidelines</b>	<b>Recommendations</b>
<b>Compression</b>	<p><b>When:</b> Used more during training and races than afterwards.</p> <p><b>Dosage:</b> 1 hour before and between 1 and 12 hours after training and races.</p> <p><b>Type:</b> Compression socks or leggings.</p>	<p><b>When:</b> Limited evidence. But suggested that it is effective if worn immediately after activity<sup>20</sup>.</p> <p><b>Dosage:</b> Inadequate evidence.</p> <p><b>Type:</b> Gradual compression<sup>20</sup>.</p>	Inadequate evidence to include compression as part of a recovery regime. More good quality research is necessary.
<b>Carbohydrates</b>	<p><b>When:</b> Before during and after races and training. Most use it within 2 hours. More used by males than females.</p> <p><b>Type:</b> Normal meal, pasta, fruit.</p>	<p><b>When:</b> Within 30 minutes after exercise<sup>33</sup>.</p> <p><b>Type:</b> Amino acids that can be easily absorbed<sup>33</sup>.</p> <p><b>Dosage:</b> 6 g.kg<sup>-1</sup> day<sup>-1</sup> to 10 g.kg<sup>-1</sup>.day<sup>-1</sup> 3,33.</p>	The use of carbohydrates should be promoted as it has been proven as a successful recovery modality.
<b>Heat</b>	<p><b>When:</b> For injury or pain.</p>	<p><b>When and dosage:</b> No recommendations available. No research support heat for during the recovery process.</p>	Heat should not form part of the recovery regime.
<b>Contrast therapy</b>	<p><b>When:</b> In pain or when racing hard.</p> <p><b>Dosage:</b> Heat for 7 min, cryotherapy for 7 minutes. End with heat</p>	<p><b>When:</b> No evidence.</p> <p><b>Dosage:</b> No good evidence. Heat for 1-3 min, cryotherapy for 1 minute<sup>19,32</sup>.</p>	Better quality research is necessary before contrast baths can be included as part of the recovery regime.

- *To determine the factors that influence endurance runners when selecting recovery modalities.*

Personal experience and information from fellow runners were the two most commonly reported factors that influenced participants' choice of different recovery modalities. This was surprising, considering that more than 70% of participants in this study had a tertiary-level qualification. While some participants reported that a health care provider or coach influenced their decision-making, the internet, books, magazines or advertisements had almost no influence on participants' choice of different recovery modalities. This creates highlights the need for peer-led educational initiatives to change practice and to promote the safe and effective use of recovery modalities.

- *To determine the knowledge endurance runners have on the perceived effectiveness of recovery modalities.*

Passive recovery and massages were perceived to be effective by most participants, followed by active recovery, stretching and cryotherapy. Carbohydrates, compression, vitamins and minerals were perceived to be the least effective recovery modalities. However, between 10% and 19% of participants indicated a lack of knowledge or no knowledge regarding the proposed mechanism of action of different recovery modalities.

- *To explore associations between the use of recovery modalities in endurance runners and socio-demographic factors such as gender, age, body mass index (BMI), monthly income, and level of education; and training and competition history.*

Demographic factors such as gender, age, level of education and monthly income were predictive of the use of carbohydrates, protein, massage, anti-inflammatory medication, active recovery and compression. Training factors associated with more experience (for example, number of marathons) were predictive of the use of vitamins and minerals, anti-inflammatory medication, active recovery and compression. The presence of a current injury was predictive of the use of anti-inflammatory medication, cryotherapy, heat, and contrast therapy.

In conclusion, this study demonstrated that there is widespread use of recovery modalities among endurance runners, despite the lack of evidence for efficacy of many modalities in enhancing recovery following endurance running. Unsafe and inappropriate practices were identified, which may compromise performance, but may also place endurance runners at risk of serious adverse events during both training and competition. A major challenge is the strong influence of personal experience and information from fellow runners on the choice of recovery modalities.

Educational initiatives, with the focus on peer-led education, are essential to encourage the safe and effective use of recovery modalities. In addition, routine pre-screening for the use of recovery modalities may promote safe participation in endurance running events.

## 5 CHAPTER FIVE: REFERENCES

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## 6 Appendix A: Invitation letter to running clubs

An invitation to participate in a research study regarding the use of Recovery modalities by Endurance Runners

To the Chair/Secretary of the Running Club

A REQUEST TO DISTRIBUTE A QUESTIONNAIRE FOR RESEARCH, TO ALL THE MEMBERS OF THE RUNNING CLUB

I am a physiotherapist currently busy with my Masters in Sports Physiotherapy at the University of Cape Town, (UCT). I am conducting a study to investigate the use of recovery modalities by endurance runners. This study has been granted ethical approval by the University of Cape Town, Faculty of Health Sciences Human Research Ethics Committee with the reference number: HREC REF 379/2013.

Recovery modalities are techniques used by athletes that increase the rate and quality of their recovery after races or training. Recovery after training and races is important to reduce fatigue, limit muscle damage and for allowing minor injuries time to heal. Recovery is a significant component of any training program in order to reduce or prevent injury and to optimize performance. Recovery modalities include nutritional substances for example protein, carbohydrates, vitamins and caffeine or activities and techniques for instance light exercise, stretching, ice and heat therapy, massages, water immersion, compression garments or simply rest.

Unfortunately it is difficult to establish a clear recovery protocol for endurance runners as there are few published studies about recovery modalities. The purpose of this study is to gain a greater understanding of the current practices of endurance runners in their choices and usage of recovery modalities. This knowledge combined with scientific evidence may help to educate runners, change behaviour and influence safe participation in sport.

Would you please distribute the participant information sheet containing a link to the online questionnaire, which is available on FluidSurvey© (<http://fluidsurveys.com/s/endurancerunners>), a Canadian-developed electronic survey tool, to all your club members?

The questionnaire will investigate endurance runners training history as well as their usage of recovery modalities. It should take the participant 15 to 30 minutes to complete the questionnaire. There will be no risk to any participant, as the questionnaire will be coded so that they remain anonymous and kept in the



strictest confidence. There is no remuneration for taking part in the study, however all participants will be provided with a useful information leaflet on the latest research on recovery modalities.

This study is being supervised by Dr Theresa Burgess, Prof Mike Lambert and Prof Andrew Bosch of the University of Cape Town. If you have any questions about the study please feel free to contact any of the individuals listed below.

Researcher:	Hanette Lemke	<a href="mailto:hanettelemke@gmail.com">hanettelemke@gmail.com</a>
Supervisor:	Dr Theresa Burgess	<a href="mailto:theresa.burgess@uct.ac.za">theresa.burgess@uct.ac.za</a>
Co-Supervisors:	Professor Mike Lambert	<a href="mailto:mike.lambert@uct.ac.za">mike.lambert@uct.ac.za</a>
	Professor Andrew Bosch	<a href="mailto:andrew.bosch@uct.ac.za">andrew.bosch@uct.ac.za</a>

You may also contact the Faculty of Health Science Human Research Ethics Committee in case you have any questions or concerns about your rights or welfare as a research participant.

Faculty of Health Sciences Human Research Ethics Committee:

Chair: Prof Marc Blockman	Telephone:	021 406 6492
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Thanking you in advance for your enthusiasm to support research within the field of Sports Physiotherapy.

Kind Regards

Hanette Lemke

BSc. Physiotherapy (University of the Free State)

## **7 Appendix B: Participant information sheet**

Research study: Recovery modalities used by Endurance Runners

Dear Endurance Runner

### **AN INVITATION TO PARTICIPATE IN A RESEARCH STUDY ABOUT RECOVERY MODALITIES**

I am a physiotherapist currently busy with my Masters in Sports Physiotherapy at the University of Cape Town, (UCT). I am conducting a study to investigate the use of recovery modalities by endurance runners. This study has been granted ethical approval by the University of Cape Town, Faculty of Health Sciences Human Research Ethics Committee with the reference number: HREC REF 379/2013.

Recovery modalities are techniques used by athletes that increase the rate and quality of their recovery after races or training. Recovery after training and races is important to reduce fatigue, limit muscle damage and for allowing minor injuries time to heal. Recovery is a significant component of any training program in order to reduce or prevent injury and to optimize performance. Recovery modalities include nutritional substances for example protein, carbohydrates, vitamins and caffeine or activities and techniques for instance light exercise, stretching, ice and heat therapy, massages, water immersion, compression garments or simply rest.

Unfortunately it is difficult to establish a clear recovery protocol for endurance runners as there are few published studies about recovery modalities. The purpose of this study is to gain a greater understanding of the current practices of endurance runners in their choices and usage of recovery modalities. This knowledge combined with scientific evidence may help to educate runners, change behaviour and influence safe participation in sport.

Any runner, running at least 30km per week, can be part of this study. If you agree to take part in this study, we will ask you to please complete an online questionnaire, which is available through a link on FluidSurvey© (<http://fluidsurveys.com/s/endurancerunners>), a Canadian-developed electronic survey tool that will be used to collect the data electronically. All data collected through FluidSurvey© is confidential and secure. Alternatively a hard copy version may be requested by contacting the research team utilising the contact details below.

The questionnaire should take you 15 to 30 minutes to complete. There will be no risk to you, as the questionnaire will be coded such that your answers remain anonymous and kept in the strictest confidence.

There is no remuneration for taking part in the study, however you will be provided with a useful information leaflet on the latest research on recovery modalities.

This study is being supervised by Dr Theresa Burgess, Prof Mike Lambert and Prof Andrew Bosch of the University of Cape Town. If you have any questions about the study please feel free to contact any of the individuals listed below.

Researcher:	Hanette Lemke	<a href="mailto:hanettelemke@gmail.com">hanettelemke@gmail.com</a>
Supervisor:	Dr Theresa Burgess	<a href="mailto:theresa.burgess@uct.ac.za">theresa.burgess@uct.ac.za</a>
Co-Supervisors:	Professor Mike Lambert	<a href="mailto:mike.lambert@uct.ac.za">mike.lambert@uct.ac.za</a>
	Professor Andrew Bosch	<a href="mailto:andrew.bosch@uct.ac.za">andrew.bosch@uct.ac.za</a>

You may also contact the Faculty of Health Science Human Research Ethics Committee in case you have any questions or concerns about your rights or welfare as a research participant.

Faculty of Health Sciences Human Research Ethics Committee:

Chair: Prof Marc Blockman	Telephone: 021 406 6492
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Thanking you in advance for your enthusiasm to support research within the field of Sports Physiotherapy.

Kind Regards

Hanette Lemke

Bsc. Physiotherapy (University of the Free State)

## 8 Appendix C: Informed consent form - Electronic version

Informed Consent: The Use of Recovery modalities by Endurance Runners

Thank you for considering participating in this study.

I am a Masters student in Sports Physiotherapy at the University of Cape Town. I am conducting a study to investigate the use of recovery modalities by endurance runners and I invite you to take part in it. This study has been given ethical approval by the Human Research Ethics Committee, Faculty of Health Sciences, University of Cape Town (Reference number: HREC REF 379/2013).

Recovery modalities are any method or product athletes use to make them feel less tired and prevent injuries after a race or training. There are a variety of products and methods that can be used for recovery after exercise. Some examples are: stretching, light exercises, massages, ice or heat therapy, compression clothing or braces, protein bars or shakes, different food or drinks, etc.

This study aims to gather information regarding the use of recovery modalities in endurance runners, and to investigate potential reasons for the selection and use of different modalities. Any runner, running at least 30km per week, can be part of this study. Should you choose to participate in the study, it would require you completing a once-off questionnaire which would take approximately 15 to 30 minutes. Your opinion will be kept anonymous and confidential.

Please answer the following questions to ensure that you can participate in the study

Are you 18 years or older?	Yes	No
Have you been running for 12 months or longer?	Yes	No
Do you run a minimum of 30 km in an average week?	Yes	No

Confirmation

I understand that I may ask questions at any time during the study. I realise that I am free to withdraw from the study without prejudice at any time, should I choose to do so. In addition, I know that the information derived from the survey will remain anonymous and confidential.

I have read this form and I understand the nature, purpose and procedure of this study. I agree to participate in this research study.

☐ ticking this box, I accept the above statement and give my full permission to participate in this study.

For any further queries, please contact:

Researcher: Hanette Lemke

Telephone: 071 331 5191

Email: [hanettelemke@gmail.com](mailto:hanettelemke@gmail.com)

Study supervisor: Dr T. Burgess

Physical Address: Division of Physiotherapy, School of Health and Rehabilitation

University of Cape Town

Groote Schuur Hospital

Anzio Road, Observatory

Telephone: 021 406 6171

E-mail: [theresa.burgess@uct.ac.za](mailto:theresa.burgess@uct.ac.za)

Study co-supervisor: Professor Mike Lambert

Physical Address: MRC/UCT Research Unit for Exercise Science and Sports Medicine

Department of Human Biology

University of Cape Town

Boundary Road, Newlands

Telephone: 021 650 4558

E-mail: [mike.lambert@uct.ac.za](mailto:mike.lambert@uct.ac.za)

Faculty of Health Sciences Human Research Ethics Committee:

Chair: Prof Marc Blockman

Telephone: 021 406 6492

## 9 Appendix D: Informed consent form - Hard copy version

Informed Consent: The Use of Recovery modalities by Endurance Runners

Thank you for considering participating in this study.

I am a Masters student in Sports Physiotherapy at the University of Cape Town. I am conducting a study to investigate the use of recovery modalities by endurance runners and I invite you to take part in it. This study has been given ethical approval by the Human Research Ethics Committee, Faculty of Health Sciences, University of Cape Town (Reference number: HREC REF 379/2013).

Recovery modalities are any method or product athletes use to make them feel less tired and prevent injuries after a race or training. There are a variety of products and methods that can be used for recovery after exercise. Some examples are: stretching, light exercises, massages, ice or heat therapy, compression clothing or braces, protein bars or shakes, different food or drinks, etc.

This study aims to gather information regarding the use of recovery modalities in endurance runners, and to investigate potential reasons for the selection and use of different modalities. Any runner, running at least 30km per week, can be part of this study. Should you choose to participate in the study, it would require you completing a once-off questionnaire which would take approximately 15 to 30 minutes. Your opinion will be kept anonymous and confidential.

Please answer the following questions to ensure that you can participate in the study

Are you 18 years or older?	Yes	No
Have you been running for 12 months or longer?	Yes	No
Do you run a minimum of 30 km in an average week?	Yes	No

Confirmation

I understand that I may ask questions at any time during the study. I realise that I am free to withdraw from the study without prejudice at any time, should I choose to do so. In addition, I know that the information derived from the survey will remain anonymous and confidential.

I have read this form and I understand the nature, purpose and procedure of this study. I agree to participate in this research study.

☐ ticking this box, I accept the above statement and give my full permission to participate in this study.

For any further queries, please contact:

Researcher: Hanette Lemke

Telephone: 071 331 5191

Email: [hanettelemke@gmail.com](mailto:hanettelemke@gmail.com)

Study supervisor: Dr T. Burgess

Physical Address: Division of Physiotherapy, School of Health and Rehabilitation

University of Cape Town

Groote Schuur Hospital

Anzio Road, Observatory

Telephone: 021 406 6171

E-mail: [theresa.burgess@uct.ac.za](mailto:theresa.burgess@uct.ac.za)

Study co-supervisor: Professor Mike Lambert

Physical Address: MRC/UCT Research Unit for Exercise Science and Sports Medicine

Department of Human Biology

University of Cape Town

Boundary Road, Newlands

Telephone: 021 650 4558

E-mail: [mike.lambert@uct.ac.za](mailto:mike.lambert@uct.ac.za)

Faculty of Health Sciences Human Research Ethics Committee:

Chair: Prof Marc Blockman

Telephone: 021 406 6492

## 10 Appendix E: Questionnaire

Please answer the following questions to ensure that you can participate in the study

Are you 18 years or older?

- ☐ Yes
- ☐ No

Have you been running for at least 6 months in the previous 12 month period?

- ☐ Yes
- ☐ No

Do you run a minimum of 30 km in an average week?

- ☐ Yes
- ☐ No

Have you completed the same questionnaire, online or in hard copy, before?

- ☐ Yes
- ☐ No

If yes, we thank you for your prior participation and do not require you to complete the questionnaire again.

### Section A

Personal Information

1. Gender

- ☐ Male
- ☐ Female



2. How old are you today?

3. Height in metres (e.g. 1.7)

4. Weight in kilograms (e.g. 70)

5. What is your highest level of education?

- ☐ Primary School
- ☐ High/Secondary School
- ☐ Standard 10/Grade 12
- ☐ College
- ☐ Technikon/University
- ☐ Adult Education Centre
- ☐ Other, please specify... \_\_\_\_\_

6. What is your monthly income?

- ☐ Less than R 1750
- ☐ R 1751-R 4000
- ☐ R 4001-R 8000
- ☐ R 8001-R 12500
- ☐ R 12501-R 17500
- ☐ R 17501-R 21000
- ☐ R 21001-R 25000

- ☐ R 25001-R 30000
- ☐ More than R 30000

**Section B:**

Medical Information

7. Do you have any current back or leg injuries that are preventing you from training as usual?

- ☐ Yes
- ☐ No

8. Do you have any chronic medical conditions?

- ☐ Yes
- ☐ No

If Yes: Please specify

- ☐ Diabetes
- ☐ Heart disease
- ☐ Hypertension/High Blood Pressure
- ☐ Stroke
- ☐ Depression
- ☐ Asthma
- ☐ Arthritis, (Please specify area/s) \_\_\_\_\_
- ☐ Cancer, (Please specify the type of cancer) \_\_\_\_\_
- ☐ Other, (Please specify) \_\_\_\_\_

## Section C

### Training Information

9. What percentage of your running do you spend on:

Track running

Road running

Trail running

Cross country running

Treadmill

10. How many years have you been running without a six month break?

11. How many times per week have you run on average for the last three months?

12. How many kilometres have you run on average per week for the last three months?

13. What is your fastest pace (minutes per kilometre) you use for training?

- ☐ Less than 3 min/km
- ☐ 3:00-3:15 min/km
- ☐ 3:16-3:30 min/km
- ☐ 3:31-3:45 min/km
- ☐ 3:46-4:00 min/km
- ☐ 4:01-4:15 min/km
- ☐ 4:16-4:30 min/km

☐ 4:31-4:45 min/km

☐ 4:46-5:00 min/km

☐ 5:01-5:15 min/km

... 17 additional choices hidden ...

☐ 9:46-10:00 min/km

☐ 10:01-10:15 min/km

☐ 10:16-10:30 min/km

☐ 10:31-10:45 min/km

☐ 10:46-11:00 min/km

☐ 11:01-11:15 min/km

☐ 11:16-11:30 min/km

☐ 11:31-11:45 min/km

☐ 11:46-12:00 min/km

☐ More than 12 min/km

14. What is your slowest pace (minutes per kilometre) you use for training?

☐ Less than 3 min/km

☐ 3:00-3:15 min/km

☐ 3:16-3:30 min/km

☐ 3:31-3:45 min/km

☐ 3:46-4:00 min/km

☐ 4:01-4:15 min/km

☐ 4:16-4:30 min/km

☐ 4:31-4:45 min/km

☐ 4:46-5:00 min/km

☐ 5:01-5:15 min/km

... 17 additional choices hidden ...

☐ 9:46-10:00 min/km

☐ 10:01-10:15 min/km

☐ 10:16-10:30 min/km

☐ 10:31-10:45 min/km

☐ 10:46-11:00 min/km

☐ 11:01-11:15 min/km

☐ 11:16-11:30 min/km

☐ 11:31-11:45 min/km

☐ 11:46-12:00 min/km

☐ More than 12 min/km

15. Does your training include any of the following?

Hill training

☐ Yes

☐ No

Speed training

☐ Yes

☐ No

Strength training

(e.g. gym work)

☐ Yes

☐ No

Stretching

☐ Yes

☐ No

Cross-training

Cross-training means training in any other sports than running, with a goal of improving your overall performance.

☐ Yes

☐ No

If Yes, please specify what activity you do to cross-train:

16. How happy are you with your current level of fitness?

☐ Very satisfied

☐ Satisfied

☐ Neutral

☐ Dissatisfied

☐ Very dissatisfied

17. How many half marathons (21 km) have you run in the last twelve months?

18. What is your best time for a half marathon (21 km) in the last twelve months?

Hours

Minutes

19. How many standard marathons (42 km) have you run in the last twelve months?

20. What is your best time for a standard marathon (42 km) in the last twelve months?

Hours

Minutes

21. How many ultramarathons (more than 50 km) have you run in the last twelve months?

22. What is your best time for an ultramarathon in the last twelve months? What distance was that ultramarathon?

Hours

Minutes

Distance of marathon in kilometres

## Section D

### Recovery Modalities

A recovery modality is any product, method or routine that you use to help your mind and body (the muscles and joints) to recover and get better quicker from stiffness, pain and tiredness after training or marathons.

23. Do you use any of the following recovery modalities? Please tick the most appropriate box(es) to indicate if and how often you use the recovery modalities. (You may tick more than 1 modality)

	Never	Rarely	Sometimes	Often	Always
Anti-inflammatory medication	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Ice/Cold	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Heat	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Combination of heat and ice	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Compression garments/bandages	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Active recovery (easy, low intensity exercise)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Passive recovery (complete rest)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Stretching	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Massage (e.g. sport massage, physio massage, Thai massage, lymotherapy)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Protein (e.g. nuts, eggs, beans, milk, yogurt, cheese, tofu, beef, chicken, fish, protein powders)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Carbohydrates or carbs (e.g. fruit, vegetables, energy drinks , rice, potato, bread, pasta, oats)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Vitamins (e.g. multi vitamin, vit A, vit C, vit D, vit B12)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Minerals (e.g. calcium, magnesium, iron)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Other, Please Specify:

Other, Please Specify:

#### A. Combination of Heat and Ice (Contrast Therapy)

i. Have you used the combination of heat and ice or contrast therapy as a recovery modality in the last 12 months?

☐ Yes

☐ No



ii. Which of the following best describes the type of ice and heat treatment you use for combination therapy? Please tick only the most appropriate box(es).

Cold	Never	Rarely	Sometimes	Often	Always
Ice/ice packs	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Cold/ice water	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Cold shower	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Cold bath	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Swimming pool/sea	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Cold towels	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Cold rub	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Ice gels	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Other, please specify

Heat	Never	Rarely	Sometimes	Often	Always
Microwave hot packs	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Hot water bottle	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Hot water or bath	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Hot shower	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Jacuzzi	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Heated towels	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Heat rub	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Infra red-light	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Other, please specify

iii. Which of the following best describes how often you include the combination of heat and ice in your training and racing program? Please tick only the most appropriate box(es).

	Never	Rarely	Sometimes	Often	Always
For ultramarathons	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
For standard marathons	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
For half marathons	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Weekly in my normal training schedule	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
When very tired	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
When in pain	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
When training or racing hard	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
When injured	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Depends on the day/No regular pattern	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

iv. With which one do you usually start?

- ☐ Cold
- ☐ Heat
- ☐ No regular pattern

v. With which one do you usually end with?

- ☐ Cold
- ☐ Heat
- ☐ No regular pattern

vi. For how many minutes do you apply the ice or cold treatment at a time?

vii. For how many minutes do you apply the heat at a time?

viii. How long will the total time be that you apply the combination of heat and ice at a time?

ix. How many times a day would you use the combination of heat and ice after a race?

x. For how many days after a race would you use the combination of heat and ice as a recovery modality?

xi. Who influenced your opinion to use the combination of heat and ice as a recovery method?

- ☐ Coach/Trainer
- ☐ Fellow runners
- ☐ Health Practitioner
- ☐ Internet
- ☐ Book/Magazine
- ☐ Adverts
- ☐ Personal experience
- ☐ Other, please specify... \_\_\_\_\_

xii. Based on your own personal experience, how effective is the combination of heat and ice as a recovery modality?

- ☐ Excellent
- ☐ Good
- ☐ Fair
- ☐ Poor
- ☐ Very poor

xiii. What do you think is the one main reason that the combination of heat and ice works?

- ☐ Reduces pain
- ☐ Reduces swelling
- ☐ Changes the flow of blood
- ☐ Speeds up energy restoration
- ☐ Reduces lactic acid build up

- ☐ Strengthens the body
- ☐ I don't know
- ☐ Other, please specify... \_\_\_\_\_

#### B. Passive Recovery

Passive recovery is complete rest from training for a day or longer.

i. Have you used passive recovery or rest as a recovery modality in the last 12 months?

- ☐ Yes
- ☐ No

ii. Which of the following best describes how often you include passive recovery or rest in your training and racing program? Please tick only the most appropriate box(es).

	N/A	Never	Rarely	Sometimes	Often	Always
For ultramarathons	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
For standard marathons	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
For half marathons	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Weekly in my normal training schedule	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
When very tired	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
When in pain	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
When training or racing hard	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
When injured	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Depends on the day/No regular pattern	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

iii. For how many days after an ultramarathon would you rest to recover?

iv. For how many days after a standard marathon would you rest to recover?

v. For how many days after a half marathon would you rest to recover?

vi. For how many days during a normal training week would you rest to recover?

vii. Who influenced your opinion to use passive recovery or complete rest as a recovery method?

- ☐ Coach/Trainer
- ☐ Fellow runners
- ☐ Health Practitioner
- ☐ Internet
- ☐ Book/Magazine
- ☐ Adverts
- ☐ Personal experience
- ☐ Other, please specify... \_\_\_\_\_

viii. Based on your own personal experience, how effective is passive recovery or complete rest as a recovery modality?

- ☐ Excellent
- ☐ Good
- ☐ Fair
- ☐ Poor
- ☐ Very poor

ix. What do you think is the one main reason that passive recovery or complete rest works?

- ☐ Reduces pain
- ☐ Reduces swelling
- ☐ Changes the flow of blood
- ☐ Speeds up energy restoration
- ☐ Reduces lactic acid build up
- ☐ Strengthens the body
- ☐ I don't know
- ☐ Other, please specify... \_\_\_\_\_

C. Heat

i. Have you used heat as a recovery modality in the last 12 months?

- ☐ Yes
- ☐ No

ii. Which of the following best describes the type of heat treatment you use? Please tick only the most appropriate box(es).

	Never	Rarely	Sometimes	Often	Always
Microwave hot packs	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Hot water bottle	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Hot water or bath	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Hot shower	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Jacuzzi	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Heated towels	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Heat rub ☐ ☐ ☐ ☐ ☐

Infra-red light ☐ ☐ ☐ ☐ ☐

Other, please specify

iii. Which of the following best describes how often you use heat as a recovery modality? Please tick only the most appropriate box(es).

	N/A	Never	Rarely	Sometimes	Often	Always
For ultramarathons	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
For standard marathons	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
For half marathons	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Weekly in my normal training schedule	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
When very tired	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
When in pain	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
When training or racing hard	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
When injured	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Depends on the day/No regular pattern	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

iv. For how many minutes do you use the heat at a time?

v. How many times a day would you use the heat after races?

vi. For how many days after a race would you use the heat as a recovery modality?

vii. Who influenced your opinion to use heat as a recovery method?

- ☐ Coach/Trainer
- ☐ Fellow runners
- ☐ Health Practitioner
- ☐ Internet

- ☐ Book/Magazine
- ☐ Adverts
- ☐ Personal experience
- ☐ Other, please specify... \_\_\_\_\_

viii. Based on your own personal experience, how effective is the heat as a recovery modality?

- ☐ Excellent
- ☐ Good
- ☐ Fair
- ☐ Poor
- ☐ Very poor

ix. What do you think is the one main reason that the heat works?

- ☐ Reduces pain
- ☐ Reduces swelling
- ☐ Changes the flow of blood
- ☐ Speeds up energy restoration
- ☐ Reduces lactic acid build up
- ☐ Strengthens the body
- ☐ I don't know
- ☐ Other, please specify... \_\_\_\_\_

#### D. Compression Clothes/Compression Bandages

i. Have you used compression clothes or bandages as a recovery modality in the last 12 months?

- ☐ Yes
- ☐ No



ii. Which of the following best describes the type of compression you use? Please tick only the most appropriate box(es).

	Never	Rarely	Sometimes	Often	Always
Full body compression suit	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Compression pants/leggings (up to hips)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Compression socks (lower than knees)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Tubigrip	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Compression bandages	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Other, please specify					

iii. Do you use compression during training?

- ☐ Yes
- ☐ No

iv. Which best describes your use of compression during training? Please tick only the most appropriate box(es) to indicate your normal use of compression garments.

	Never	Rarely	Sometimes	Often	Always
Before training	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
During training	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
After training	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
When very tired	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
When training hard	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
When injured	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
When in pain	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Depends on the day/No regular pattern	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

v. Do you use compression for races?

☐ Yes

☐ No

vi. Which best describes your use of compression during races? Please tick only the most appropriate box(es).

	N/A	Never	Rarely	Sometimes	Often	Always
Before half marathons	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
During half marathons	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
After half marathons	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Before standard marathons	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
During standard marathons	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
After standard marathons	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Before ultramarathons	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
During ultramarathons	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
After ultramarathons	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
When training or racing hard	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
When very tired	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
When in pain	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
When injured	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Depends on the day/No regular pattern	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

vii. For how long would you use compression before a race?

viii. For how long would you use compression after a race?

ix. For how many days after a race would you use compression as a recovery modality?

x. Who influenced your opinion to use compression as a recovery method?

- ☐ Coach/Trainer
- ☐ Fellow runners
- ☐ Health Practitioner
- ☐ Internet
- ☐ Book/Magazine
- ☐ Adverts
- ☐ Personal experience
- ☐ Other, please specify... \_\_\_\_\_

xi. Based on your own personal experience, how effective is compression as a recovery modality?

- ☐ Excellent
- ☐ Good
- ☐ Fair
- ☐ Poor
- ☐ Very poor

xiii. What do you think is the one main reason that compression works?

- ☐ Reduces pain
- ☐ Reduces swelling
- ☐ Changes the flow of blood
- ☐ Speeds up energy restoration
- ☐ Reduces lactic acid build up
- ☐ Strengthens the body

- ☐ I don't know
- ☐ Other, please specify... \_\_\_\_\_

#### E. Active Recovery/Exercise

Active recovery is an easy, low intensity training session or exercise, for example a light run or easy cross training session, to help you to recover from training or a race

i. Have you used active recovery or exercise as a recovery modality in the last 12 months?

- ☐ Yes
- ☐ No

ii. Which of the following best describes the type of active recovery or exercise you use? Please tick only the most appropriate box(es).

	Never	Rarely	Sometimes	Often	Always
Running	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Walking	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Cycling	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Swimming	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Gym	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Other, please specify

iii. Which of the following best describes how often you include active recovery in your training and racing program? Please tick only the most appropriate box(es).

	N/A	Never	Rarely	Sometimes	Often	Always
For ultramarathons	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
For standard marathons	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

For half marathons	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Weekly in my normal training schedule	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
When very tired	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
When in pain	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
When training or racing hard	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
When injured	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Depends on the day/No regular pattern	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

iv. For how many minutes do you use active recovery or exercise at a time?

v. How many times a day would you exercise as a recovery modality after a race?

vi. For how many days after a race would you use exercise as a recovery modality?

vii. Who influenced your opinion to use active recovery or exercise as a recovery method?

- ☐ Coach/Trainer
- ☐ Fellow runners
- ☐ Health Practitioner
- ☐ Internet
- ☐ Book/Magazine
- ☐ Adverts
- ☐ Personal experience
- ☐ Other, please specify... \_\_\_\_\_

viii. Based on your own personal experience, how effective is active recovery or exercise as a recovery modality?

- ☐ Excellent
- ☐ Good
- ☐ Fair

- ☐ Poor
- ☐ Very poor

ix. What do you think is the one main reason that active recovery or exercise works?

- ☐ Reduces pain
- ☐ Reduces swelling
- ☐ Changes the flow of blood
- ☐ Speeds up energy restoration
- ☐ Reduces lactic acid build up
- ☐ Strengthens the body
- ☐ I don't know
- ☐ Other, please specify... \_\_\_\_\_

#### F. Stretching

i. Have you used stretching as a recovery modality in the last 12 months?

- ☐ Yes
- ☐ No

ii. What part of your body do you usually stretch? Please tick only the most appropriate box(es).

	Never	Rarely	Sometimes	Often	Always
Front of upper legs	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Back of upper legs	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Calves/lower legs	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Groin (Front of hip)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Buttocks	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Back                      ☐        ☐        ☐                      ☐        ☐

Arms                      ☐        ☐        ☐                      ☐        ☐

Neck                      ☐        ☐        ☐                      ☐        ☐

Other, please specify

iii. Do you use stretching during training?

☐ Yes

☐ No

iv. Which of the following best describes how often you include stretching in your training program? Please tick only the most appropriate box(es).

	Never	Rarely	Sometimes	Often	Always
Before training	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
During training	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
After training	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
When very tired	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
When training hard	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
When injured	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
When in pain	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Depends on the day/No regular pattern	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

v. Do you stretch when running races?

☐ Yes

☐ No

vi. Which best describes how often you include stretching during a race? Please tick only the most appropriate box(es).

	N/A	Never	Rarely	Sometimes	Often	Always
Before half marathons	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
During half marathons	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
After half marathons	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Before standard marathons	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
During standard marathons	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
After standard marathons	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Before ultramarathons	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
During ultramarathons	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
After ultramarathons	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
When training or racing hard	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
When very tired	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
When in pain	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
When injured	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Depends on the day/No regular pattern	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

vii. For how long do you hold each stretch?

- ☐ I do dynamic stretching, so I don't hold it
- ☐ 1-5 seconds
- ☐ 6-10 seconds
- ☐ 11-15 seconds
- ☐ 16-20 seconds
- ☐ 21-25 seconds



- ☐ 25-30 seconds
- ☐ 31-35 seconds
- ☐ 36-40 seconds
- ☐ 41-45 seconds
- ☐ 46-50 seconds
- ☐ 51-55 seconds
- ☐ 56-60 seconds
- ☐ 61-90 seconds
- ☐ 91-120 seconds
- ☐ Longer than 120 seconds

viii. How many times do you repeat each stretch?

ix. How many times a week do you normally stretch?

x. For how many days before a race would you stretch as a recovery modality?

xi. For how many days after a race would you stretch as a recovery modality?

xii. Who influenced your opinion to stretch as a recovery method?

- ☐ Coach/Trainer
- ☐ Fellow runners
- ☐ Health Practitioner
- ☐ Internet
- ☐ Book/Magazine
- ☐ Adverts
- ☐ Personal experience
- ☐ Other, please specify... \_\_\_\_\_

xiii. Based on your own personal experience, how effective is stretching as a recovery modality?

- ☐ Excellent
- ☐ Good
- ☐ Fair
- ☐ Poor
- ☐ Very poor

xiv. What do you think is the one main reason that stretching works?

- ☐ Reduces pain
- ☐ Reduces swelling
- ☐ Changes the flow of blood
- ☐ Speeds up energy restoration
- ☐ Reduces lactic acid build up
- ☐ Strengthens the body
- ☐ I don't know
- ☐ Other, please specify... \_\_\_\_\_

#### G. Messages

i. Have you used massages as a recovery modality in the last 12 months?

- ☐ Yes
- ☐ No

ii. To whom do you go for a massage? Please tick only the most appropriate box(es).

Never   Rarely   Sometimes   Often   Always

Trainer/coach      ☐      ☐      ☐      ☐      ☐

Friend/family	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Physiotherapist	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Lynotherapist	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Chiropractor	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Sport massage therapist	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Thai massage therapist	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Chinese massage therapist	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Beautician	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Other, please specify

iii. Which of the following best describes how often you include massages in your training and racing program? Please tick only the most appropriate box(es).

N/A	Never	Rarely	So SHAPE \* MERGEFORMAT or	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
			ultramarathons						
For standard marathons	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>		<input type="radio"/>	<input type="radio"/>	<input type="radio"/>		
For half marathons	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>		<input type="radio"/>	<input type="radio"/>	<input type="radio"/>		
Weekly in my normal training schedule	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>		<input type="radio"/>	<input type="radio"/>	<input type="radio"/>		
When in pain	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>		<input type="radio"/>	<input type="radio"/>	<input type="radio"/>		
When training or racing hard	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>		<input type="radio"/>	<input type="radio"/>	<input type="radio"/>		
When injured	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>		<input type="radio"/>	<input type="radio"/>	<input type="radio"/>		
Depends on the day/No regular pattern	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>		<input type="radio"/>	<input type="radio"/>	<input type="radio"/>		

iv. How long does the massage usually last?

v. For how many days after a race would you use massages as a recovery modality

vi. Who influenced your opinion to use massages as a recovery method?

- ☐ Coach/Trainer
- ☐ Fellow runners
- ☐ Health Practitioner
- ☐ Internet
- ☐ Book/Magazine
- ☐ Adverts
- ☐ Personal experience
- ☐ Other, please specify... \_\_\_\_\_

vii. Based on your own personal experience, how effective do you think massage is as a recovery modality?

- ☐ Excellent
- ☐ Good
- ☐ Fair
- ☐ Poor
- ☐ Very poor

viii. What do you think is the one main reason that massages works?

- ☐ Reduces pain
- ☐ Reduces swelling
- ☐ Changes the flow of blood
- ☐ Speeds up energy restoration
- ☐ Reduces lactic acid build up
- ☐ Strengthens the body
- ☐ I don't know

#### H. Protein, Amino-Acids

Examples of food and drinks containing protein and amino acids are nuts, beans, eggs, milk, yogurt, cheese, tofu, beef, chicken, pork, fish and protein shakes or powders.

i. Have you consumed extra protein in your diet as a recovery modality in the last 12 months?

☐ Yes

☐ No

ii. Which of the following best describes the type of protein or amino acids you use? Please tick only the most appropriate box(es).

	Never	Rarely	Sometimes	Often	Always
Normal meal with the same amount of protein	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Normal meal with extra protein	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Milk	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Flavoured milk	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Eggs	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Protein bar	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Protein shake or drink	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Other protein supplements	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Other, please specify

iii. Do you include extra protein in your normal diet for training?

☐ Yes

☐ No

iv. Which of the following best describes how you change your normal diet to include extra protein to your diet when you are training? Please tick the most appropriate box(es).

	Never	Rarely	Sometimes	Often	Always
Before training	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
During training	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
After training	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
When very tired	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
When training hard	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
When injured	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
When in pain	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Depends on the day/No regular pattern	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

iv. Do you include extra protein in your diet for races?

vi. Which best describes how often you include extra protein during races? Please tick only the most appropriate box(es).

	N/A	Never	Rarely	Sometimes	Often	Always
Before half marathons	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
During half marathons	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
After half marathons	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Before standard marathons	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
During standard marathons	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
After standard marathons	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Before ultramarathons	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
During ultramarathons	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
After ultramarathons	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

When training or racing hard	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
When very tired	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
When injured	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Depends on the day/No regular pattern	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

vii. For how many days before a race would you eat or drink extra protein?

viii. How often do you eat or drink extra protein during a race? Please note: You can choose more than one

- ☐ N/A
- ☐ 1-30 min
- ☐ 30-60 min
- ☐ 61-90 minutes
- ☐ 91 min-2 hourly
- ☐ 3 hourly
- ☐ 4 hourly
- ☐ 5 hourly
- ☐ >5 hourly
- ☐ Only when hungry
- ☐ Only when I feel like it
- ☐ Only when tired
- ☐ Never

ix. How soon after the race would you eat or drink extra protein as a recovery modality?

Please note: You can choose more than one option

- ☐ N/A
- ☐ Within the first 30 minutes

- ☐ 31-60 min after
- ☐ 61-90 minutes after
- ☐ 91 min-2 hour after
- ☐ More than 2 hours after
- ☐ At my next meal
- ☐ Only when hungry
- ☐ Only when I feel like it
- ☐ Only when tired

x. For how many days after a race would you eat or drink extra protein?

xi. Who influenced your opinion to eat or drink extra protein as a recovery method?

- ☐ Coach/Trainer
- ☐ Fellow runners
- ☐ Health Practitioner
- ☐ Internet
- ☐ Book/Magazine
- ☐ Adverts
- ☐ Personal experience
- ☐ Other, please specify... \_\_\_\_\_

xii. Based on your own personal experience, how effective do you think extra protein is as a recovery modality?

- ☐ Excellent
- ☐ Good
- ☐ Fair
- ☐ Poor



☐ Very poor

xiii. What do you think is the one main reason that the extra protein works?

☐ Reduces pain

☐ Reduces swelling

☐ Changes the flow of blood

☐ Speeds up energy restoration

☐ Reduces lactic acid build up

☐ Strengthens the body

☐ I don't know

☐ Other, please specify... \_\_\_\_\_

#### I. Carbohydrate

Examples of food containing carbohydrates are fruit, vegetables, energy drinks and starches for instance rice, potato, bread, pasta and cereals.

i. Have you consumed extra carbohydrates in your normal diet as a recovery modality in the last 12 months?

☐ Yes

☐ No

ii. Which of the following best describes the type of carbohydrates you use? Please tick only the most appropriate box(es).

	Never	Rarely	Sometimes	Often	Always
Normal meal with the normal amount of carbohydrates	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Normal meal with an increase amount of carbohydrates	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Pasta	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Rice	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Potato	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Sandwich	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Fruit	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Protein bar	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Gu or equivalent	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Shake	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Sports drink	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Soda drink	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Fruit juice	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Other, please specify					

iii. Do you include extra carbohydrates in your normal diet for training?

- ☐ Yes
- ☐ No

iv. Which of the following best describes how you change your normal diet to include extra carbohydrates to your diet when you are training? Please tick the most appropriate box(es).

	Never	Rarely	Sometimes	Often	Always
Before training	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
During training	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
After training	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
When very tired	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
When training hard	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
When injured	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

When in pain ☐ ☐ ☐ ☐ ☐

Depends on the day/No regular pattern ☐ ☐ ☐ ☐ ☐

v. Do you include extra carbohydrates in your diet for races?

☐ Yes

☐ No

vi. Which best describes how often you include extra carbohydrates during races? Please tick the most appropriate box(es).

	N/A	Never	Rarely	Sometimes	Often	Always
Before half marathons	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
During half marathons	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
After half marathons	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Before standard marathons	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
During standard marathons	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
After standard marathons	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Before ultramarathons	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
During ultramarathons	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
After ultramarathons	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
When training or racing hard	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
When very tired	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
When in pain	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
When injured	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Depends on the day/No regular pattern	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

vii. Do you “carbo load” before a race?

☐ N/A

- ☐ Never
- ☐ Rarely
- ☐ Sometimes
- ☐ Often
- ☐ Always

viii. For how many days before a race would you increase your carbohydrate intake?

ix. How often do you eat or drink extra carbohydrates during a race?

Please note: You can choose more than one option

- ☐ 1-30 min
- ☐ 30-60 min
- ☐ 61-90 minutes
- ☐ 91 min-2 hourly
- ☐ 3 hourly
- ☐ 4 hourly
- ☐ 5 hourly
- ☐ >5 hourly
- ☐ Only when hungry
- ☐ Only when I feel like it
- ☐ Only when tired
- ☐ Never
- ☐ N/A

x. How soon after a race would you eat or drink extra carbohydrates as a recovery modality?

Please note: You can choose more than one option

- ☐ Within the first 30 minutes
- ☐ 31-60 min after
- ☐ 61-90 minutes after
- ☐ 91 min-2 hour after
- ☐ More than 2 hours after
- ☐ At my next meal
- ☐ Only when hungry
- ☐ Only when I feel like it
- ☐ Only when tired
- ☐ N/A

xi. For how many days after a race would you eat or drink extra carbohydrates?

xii. Who influenced your opinion to eat or drink extra carbohydrates as a recovery method?

- ☐ Coach/Trainer
- ☐ Fellow runners
- ☐ Health Practitioner
- ☐ Internet
- ☐ Book/Magazine
- ☐ Adverts
- ☐ Personal experience
- ☐ Other, please specify... \_\_\_\_\_

xiii. Based on your own personal experience, how effective do you think extra carbohydrates is as a recovery modality?

- ☐ Excellent
- ☐ Good
- ☐ Fair
- ☐ Poor
- ☐ Very poor

xiv. What do you think is the one main reason that the extra carbohydrates works?

- ☐ Reduces pain
- ☐ Reduces swelling
- ☐ Changes the flow of blood
- ☐ Speeds up energy restoration
- ☐ Reduces lactic acid build up
- ☐ Strengthens the body
- ☐ I don't know
- ☐ Other, please specify... \_\_\_\_\_

#### J. Vitamin and Mineral Supplements

i. Have you used extra vitamin or mineral supplements in your diet as a recovery modality in the last 12 months?

- ☐ Yes
- ☐ No

ii. Do you take vitamin or mineral supplements as a daily habit even if you are not training?

- ☐ Never
- ☐ Rarely

- ☐ Sometimes
- ☐ Often
- ☐ Always
- ☐ Only when I am sick or injured

iii. Which of the following best describes the type of vitamin and mineral supplements you use? Please tick only the most appropriate box(es).

	Never	Rarely	Sometimes	Often	Always
Multivitamins	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Vitamin A	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Vitamin B12	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Vitamin C	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Vitamin D	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Vitamin E	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Calcium	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Magnesium	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Iron	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Other, please specify

iv. Which of the following best describes how often you include vitamin or mineral supplements in your training and racing program? Please tick only the most appropriate box(es).

	N/A	Never	Rarely	Sometimes	Often	Always
For ultramarathons	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
For standard marathons	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
For half marathons	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Weekly in my normal training schedule	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
When very tired	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
When in pain	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
When training or racing hard	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
When injured	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Depends on the day/No regular pattern	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

v. For how many days before a race would you increase your vitamin and mineral supplement intake?

vi. For how many days after a race would you increase your vitamin and mineral supplement intake?

vii. Who influenced your opinion to take vitamin and mineral supplements as a recovery method?

- ☐ Coach/Trainer
- ☐ Fellow runners
- ☐ Health Practitioner
- ☐ Internet
- ☐ Book/Magazine
- ☐ Adverts
- ☐ Personal experience
- ☐ Other, please specify... \_\_\_\_\_

viii. Based on your own personal experience, how effective do you think taking vitamin and mineral supplements is as a recovery modality?

- ☐ Excellent
- ☐ Good
- ☐ Fair
- ☐ Poor
- ☐ Very poor



ix. What do you think is the one main reason that the vitamin and mineral supplements work?

- ☐ Reduces pain
- ☐ Reduces swelling
- ☐ Changes the flow of blood
- ☐ Speeds up energy restoration
- ☐ Reduces lactic acid build up
- ☐ Strengthens the body
- ☐ I don't know
- ☐ Other, please specify... \_\_\_\_\_

#### K. Anti-inflammatory Medication

i. Have you used anti-inflammatory medication as a recovery modality in the last 12 months?

- ☐ Yes
- ☐ No

ii. What anti-inflammatory medication do you use? Please tick only the appropriate box(es) to indicate which of the following best describes what and how often you use anti-inflammatory medication.

	Never	Rarely	Sometimes	Often	Always
Advil	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Aleve	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Aspirin	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Cataflam D	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Celebrax	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Ibuprofen	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Myprodol	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Naproxen	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Norflex	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Panamor	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Traumeel	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Toradol	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Transact Patch	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Voltaren	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Other, please specify

iii. What type of anti-inflammatory application do you use? Please tick only the appropriate box(es) to indicate which of the following best describes the type of anti-inflammatory application you use.

	Never	Rarely	Sometimes	Often	Always
Tablet/Pill	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Suppository	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Gel/Cream	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Spray	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Patch	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Injection	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Other, please specify

iv. Do you use anti-inflammatory medication during training?

☐ Yes

☐ No

v. Which best describes your use of anti-inflammatory medication when you are training? Please tick only the appropriate box(es) to indicate your normal use of anti-inflammatory medication.

	Never	Rarely	Sometimes	Often	Always
Before training	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
During training	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
After training	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
When very tired	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
When training hard	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
When injured	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
When in pain	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Depends on the day/No regular pattern	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

vi. Do you use anti-inflammatory medication before, during or after  races ?

- ☐ Yes
- ☐ No

vii. Which best describes your use of anti-inflammatory medication before, during or after races? Please tick only the appropriate box(es) to indicate your normal use of anti-inflammatory medication.

	N/A	Never	Rarely	Sometimes	Often	Always
Before half marathons	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
During half marathons	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
After half marathons	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Before standard marathons	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
During standard marathons	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
After standard marathons	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Before ultramarathons	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

During ultramarathons	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
After ultramarathons	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
When very tired	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
When in pain	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
When racing hard	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
When injured	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Depends on the day/No regular pattern	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

viii. How often would you use anti-inflammatory medication during normal training?

- ☐ Once a day
- ☐ Twice a day
- ☐ Three times a day
- ☐ Four times a day
- ☐ Five times a day
- ☐ More than six times a day
- ☐ Only when I feel pain
- ☐ Only when I feel tired
- ☐ No specific pattern
- ☐ Never

ix. How often would you use anti-inflammatory medication during races?

- ☐ 1-60 minutes
- ☐ 61 minutes – 2 hours
- ☐ Every 3 hours
- ☐ Every 4 hours

- ☐ Every 5 hours
- ☐ Every 6 hours
- ☐ Every 7 hours
- ☐ Every 8 hours
- ☐ > 8 hours
- ☐ Only when I feel pain
- ☐ Only when I feel tired
- ☐ No specific pattern
- ☐ Never

x. How many times a day would you use anti-inflammatory medication after races?

- ☐ Once a day
- ☐ Twice a day
- ☐ Three times a day
- ☐ Four times a day
- ☐ Five times a day
- ☐ More than six times a day
- ☐ Only when I feel pain
- ☐ Only when I feel tired
- ☐ No specific pattern
- ☐ Never

xi. For how many days after a race would you use anti-inflammatory medication as a recovery modality?

xii. Who influenced your opinion to use anti-inflammatory medication as a recovery method?

- ☐ Coach/Trainer

- ☐ Fellow runners
- ☐ Health Practitioner
- ☐ Internet
- ☐ Book/Magazine
- ☐ Adverts
- ☐ Personal experience
- ☐ Other, please specify... \_\_\_\_\_

xiii. Based on your own personal experience, how effective is anti-inflammatory medication as a recovery modality?

- ☐ Excellent
- ☐ Good
- ☐ Fair
- ☐ Poor
- ☐ Very poor

xiv. What do you think is the one main reason that the anti-inflammatory medication works?

- ☐ Reduces pain
- ☐ Reduces swelling
- ☐ Changes the flow of blood
- ☐ Speeds up energy restoration
- ☐ Reduces lactic acid build up
- ☐ Strengthens the body
- ☐ I don't know
- ☐ Other, please specify... \_\_\_\_\_

## L. Ice and Cold Treatment

i. Have you used ice or cold treatment as a recovery modality in the last 12 months?

☐ Yes

☐ No

ii. Which of the following best describes the type of ice or cold treatment you use? Please tick only the appropriate box(es).

	Never	Rarely	Sometimes	Often	Always
Ice/ice packs	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Cold/ice water	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Cold shower	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Cold bath	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Swimming pool/sea	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Cold towels	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Cold rub	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Ice gels	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Other, please specify

iii. Which of the following best describes how often you use ice or cold treatment? Please tick only the most appropriate box(es).

	N/A	Never	Rarely	Sometimes	Often	Always
For ultramarathons	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
For standard marathons	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
For half marathons	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
When very tired	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

When in pain	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
When training or racing hard	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
When injured	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Depends on the day/No regular pattern	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

iv. For how many minutes do you use the cold treatment at a time?

v. How many times a day would you use the cold treatment after races?

vi. For how many days after a race would you use the cold treatment as a recovery modality?

vii. Who influenced your opinion to use cold treatment as a recovery method?

- ☐ Coach/Trainer
- ☐ Fellow runners
- ☐ Health Practitioner
- ☐ Internet
- ☐ Book/Magazine
- ☐ Adverts
- ☐ Personal experience
- ☐ Other, please specify... \_\_\_\_\_

viii. Based on your own personal experience, how effective is the ice or cold treatment as a recovery modality?

- ☐ Excellent
- ☐ Good
- ☐ Fair
- ☐ Poor
- ☐ Very poor



ix. What do you think is the one main reason that the cold treatment works?

- ☐ Reduces pain
- ☐ Reduces swelling
- ☐ Changes the flow of blood
- ☐ Speeds up energy restoration
- ☐ Reduces lactic acid build up
- ☐ Strengthens the body
- ☐ I don't know
- ☐ Other, please specify... \_\_\_\_\_

M. Other Recovery modalities

i. Have you used any other recovery modalities, not mentioned in this questionnaire, in the past 12 months?

- ☐ Yes
- ☐ No

Please specify:

ii. Which of the following best describes how often you include this recovery modality in your training program? Please tick only the most appropriate box(es).

	N/A	Never	Rarely	Sometimes	Often	Always
For ultramarathons	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
For standard marathons	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
For half marathons	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Weekly in my normal training schedule	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
When very tired	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

When in pain	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
When training or racing hard	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
When injured	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Depends on the day/No regular pattern	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

iii. For how many days before a race would you use this recovery modality?

iv. For how many days after a race would you use this recovery modality?

v. Who influenced your opinion to use this recovery modality?

- ☐ Coach/Trainer
- ☐ Fellow runners
- ☐ Health Practitioner
- ☐ Internet
- ☐ Book/Magazine
- ☐ Adverts
- ☐ Personal experience
- ☐ Other, please specify... \_\_\_\_\_

vi. Based on your own personal experience, how effective do you think this recovery modality is?

- ☐ Excellent
- ☐ Good
- ☐ Fair
- ☐ Poor
- ☐ Very poor

vii. What do you think is the one main reason that the recovery modality works?

- ☐ Reduces pain

- ☐ Reduces swelling
- ☐ Changes the flow of blood
- ☐ Speeds up energy restoration
- ☐ Reduces lactic acid build up
- ☐ Strengthens the body
- ☐ I don't know
- ☐ Other, please specify... \_\_\_\_\_

N. Other Recovery modalities

i. Have you used any other recovery modalities, not mentioned in this questionnaire, in the past 12 months?

- ☐ Yes
- ☐ No

Please specify:

ii. Which of the following best describes how often you include this recovery modality in your training program? Please tick only the most appropriate box(es).

	N/A	Never	Rarely	Sometimes	Often	Always
For ultramarathons	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
For standard marathons	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
For half marathons	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Weekly in my normal training schedule	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
When very tired	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
When in pain	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

When training or racing hard                      ☐   ☐   ☐   ☐                      ☐   ☐

When injured    ☐   ☐   ☐   ☐    ☐   ☐

Depends on the day/No regular pattern   ☐   ☐   ☐   ☐                      ☐   ☐

iii. For how many days before a race would you use this recovery modality?

iv. For how many days after a race would you use this recovery modality?

v. Who influenced your opinion to use this recovery modality?

- ☐ Coach/Trainer
- ☐ Fellow runners
- ☐ Health Practitioner
- ☐ Internet
- ☐ Book/Magazine
- ☐ Adverts
- ☐ Personal experience
- ☐ Other, please specify... \_\_\_\_\_

vi. Based on your own personal experience, how effective do you think this recovery modality is?

- ☐ Excellent
- ☐ Good
- ☐ Fair
- ☐ Poor
- ☐ Very poor

vii. What do you think is the one main reason that the recovery modality works?

- ☐ Reduces pain
- ☐ Reduces swelling

- ☐ Changes the flow of blood
- ☐ Speeds up energy restoration
- ☐ Reduces lactic acid build up
- ☐ Strengthens the body

## **11 Appendix F: Information leaflet**

### **Training and Recovery for Endurance Athletes**

Endurance training programs need careful planning to ensure that the benefits of strengthening and running are gained, while avoiding or minimising fatigue and injuries. A good training program needs to consider a few important components. Firstly, the strength and flexibility of the anatomical structures such as the muscles and joint, secondly the type of stress or load during exercise, thirdly the frequency, intensity and duration of the exercise and finally the recovery techniques and time between training sessions.

### **Overreaching**

Athletes often train very hard for a specific time, increasing the volume and intensity to build more muscle strength and to increase endurance. This is called overreaching. Overreaching is crucial for athletes to increase performance. Adequate recovery techniques help to maximise this process. However, when overreaching is done without sufficient recovery time it may lead to increased fatigue and reduced performance. Overtraining or overtraining syndrome is a chronic over trained state that causes physical, emotional and behavioural symptoms that can last weeks to months. Unfortunately overtraining syndrome is very common. Between 15 to 50 % of competitive endurance athletes can suffer from overtraining syndrome in a season due to overtraining and insufficient recovery processes. Finding a balance between training, competition and recovery is thus a major challenge.

A balance between training load and recovery is important to prevent running-related injuries and maximize performance. Athletes often have a busy schedule with little time between training sessions and races. Therefore using specific techniques that can assist with recovery are crucial to enable athletes to maintain performance when optimal recovery is not possible.

### **Recovery**

Optimal recovery is when all the tissues and systems in the body return to their normal state after intensive or prolonged training. Breakdown of the muscle protein can continue even after the training has stopped. Recovery is crucial after an intense session or eccentric training to repair damaged muscle fibres and to renew the energy stores.

The goals of recovery should be to assist in the repair of damage tissues, to decrease pain and to restore the normal function of the body. Due to the nature of endurance running, athletes have intensive training

schedules and regularly partake in competition on consecutive days. The “more is better” principle during endurance sport often causes athletes and coaches to overlook recovery.

### **Recovery Modalities**

A planned recovery process may include different recovery modalities where each has a specific goal during the recovery process. Different fitness levels and training methods require different recovery modalities. Recovery modalities are any techniques used by athletes that increase the rate and quality of their recovery after competition or training. Unfortunately, scientific evidence for the effectiveness of different recovery modalities is limited and of poor quality. Runners often use the recovery modalities that elite athletes, coaches and advertising agencies recommend rather than what scientific data prescribes.

Recovery modalities can and should include nutritional substances such as protein, carbohydrates and vitamins to replace depleted energy stores and to assist with muscle and tissue healing. It commonly includes other activities and techniques such as light exercise known as active recovery, stretching, massages, compression garments, different types of cold or heat water immersion, or complete rest to enable the body to recover faster. The following section discusses the different types of recovery modalities.

### **Anti-Inflammatory Medication (NSAIDS)**

Athletes all over the world use non-steroidal anti-inflammatory drugs (NSAIDS) regularly to decrease pain, assist with recovery and to accelerate their return to sports. NSAIDS are often used as a preventative tool and have potential to improve performance. NSAIDS have an inhibitory effect on the initial inflammatory response, influencing the healing phase of the body. NSAIDS can therefore impair the repair process of the body as they change the natural healing process after an injury.

Although NSAIDS has been showed to reduce pain and improve function after an acute injury it cause multiple harmful side effects that are often overlooked to achieve the short term goal of decreased pain and increased recovery. Despite all the side effects of NSAIDS it is still widely used. Regular use of NSAIDS can lead to side effects of the gastrointestinal systems. It can also cause dehydration and liver and kidney disorders. There is good evidence for the effective use of NSAIDS in short term pain relief, but as NSAIDS are not much more effective than Paracetamol, it is recommended that NSAIDS only been used when justified in specific situations. The minimal effective dose for the shortest amount of time should then be prescribed. The use of Paracetamol, instead of NSAIDS is recommended in the initial 48 hours after an injury to promote adequate tissue healing. **It is widely recommended to avoid using NSAIDS during sport, due to their negative effect of on soft tissue healing and the multiple side effects associated with them.**

## Nutritional Recovery Modalities

Adequate nutrition is recommended and crucial for the body to function optimal during sport. Multiple factors play a role in determining adequate nutrition. These factors include the type of exercise, duration and intensity, the level of training, gender and the nutritional and hydration status of an athlete. As a rule exercise lasting for longer than one hour needs additional nutrition.

Nutrition influences the performance of athletes, especially endurance athletes, as they require higher energy levels and extra protein intake to ensure adequate muscle function. Athletes need adequate energy intake for prolonged or intense training to avoid the loss of muscle mass and bone density, menstrual dysfunction, fatigue, illness and prolonged recovery.

Endurance athletes burn mostly carbohydrate and fat as fuel during exercise but 1-6% of energy used comes from protein. When the carbohydrate is burned up during endurance exercise, protein becomes a more important fuel. In order to improve recovery it is recommended to:

- To consume carbohydrates to replace muscle energy
- Consume protein to repair and build muscles
- Optimize fluid intake to ensure normal electrolyte balance
- Gels, bars and sports drinks are dietary supplements that can be a very convenient supplement for active people.

## Protein

Protein is an important source of energy. Optimal protein intake should be between 0.8 to 1.8 g/kg of body weight. About 0.8 g/kg/day is enough protein for a non-exercising male older than 19 years but may be not enough to support the protein needed during exercise or for the repair of muscles after exercise. The International Society of Sports Nutrition and most other literature recommend 1.0g/kg to 1.6 g/kg per day for endurance exercise depending on the fitness of the athlete and the duration and intensity of the training programme. As the intensity and duration of training programs increase, additional protein is needed to ensure performance and optimal recovery. But no extra protein supplements are required for recreational athletes on a normal balanced diet, performing low to moderate training.

Some popular believes are that chronic intake of increased amounts of protein is harmful to the kidneys and could cause renal failure; or that it increases the risk of osteoporosis, as a high protein diet can increase the excretion of calcium. Both these believes are unfounded as there are no evidence of harmful effects of ingesting high amounts of protein in a healthy active person.



## **Carbohydrates and Glycogen**

Glycogen or carbohydrates is the primary fuel source for intermittent high intensity exercise or sub maximal exercise such as endurance exercise and are effective as a recovery modality. Carbohydrates maintain the blood glucose levels during exercise. Depending on an athlete's training program between 6 g/kg/day to 10 g/kg/day of carbohydrate is recommended.

Carbohydrate loading has been around for many years and is one method that is used to ensure adequate glycogen stores. Carbohydrate loading can consist of a low-carbohydrate diet while training for a week and then to switch to a high-carbohydrate diet combined with rest for the three days prior to competition. More recent research showed that the low-carbohydrate diet is unnecessary and only three days of high-carbohydrate is necessary prior to competition to ensure sufficient glycogen stores. They found that it is possible to replenish the glycogen stores in 24 hours.

Renewal of the glycogen stores has been showed to be higher than when carbohydrate is consumed directly after exercise than two hours later. The frequency that carbohydrate is consumed or the form it is in does not seem to matter.

## **Vitamins**

Although vitamins are consumed in small amounts it is vital to regulate health and the function of a body. Vitamins can be classified as water or fat soluble. Important water soluble vitamins are vitamin C and vitamin B. Vitamin B regulates the carbohydrate, fat and protein metabolism. Therefore vitamin B has a role in energy metabolism. Vitamin C has an effect on the recovery process from intense training and acts like an anti-oxidant. It can boost the immune system. Vitamin C deficiency can increase fatigue and reduce energy. Intense or endurance exercise can cause temporary immune-depression in athletes, making them prone to infections such as upper respiratory tract infections.

Vitamin A, vitamin D and vitamin E are fat soluble vitamins. They have an indirect influence on energy metabolism. Vitamin A and vitamin E help with reducing muscle damage and supporting recovery after exercise.

Athletes often use mineral and vitamin supplements; mostly to compensate for inadequate diets, to provide extra nutrient and energy during intense training programs, to aid their performance or to prevent illness and infection. Scientific studies have shown that most physical active adults consume an adequate amount of vitamin C. Therefore a diet that includes a variety of foods ensures adequate vitamins and minerals and reduces the need for added vitamin and mineral supplements.

## **Cryotherapy/Cold Treatment**

Cryotherapy is the cooling of a part of the body. Cryotherapy cools the skin and the underlying tissues of the body. It alters the blood flow by causing blood vessel constriction, reducing the swelling and pain. If combined with water immersion the pressure of the water can move fluids from the legs or arms to the heart. Examples of cryotherapy are cold water immersion, such as swimming in a cold pool or the application of ice packs.

### **Icepacks**

Cold and heat are legal methods to enhance performance during sport. The use of locally applied ice decreases the skin and underlying tissues' temperature causing vasoconstriction of the blood vessels with reduced blood flow and a decreased metabolism for the area. This can reduce inflammation, swelling, pain and the injury

Lately there is some thought regarding the possibility that ice might decrease the muscle adaptation or training effect of the muscle after training. Some possible negative effects of ice application on athletic performance have been noted previously. It is therefore recommended that ice should only be used after a specific injury.

### **Contrast Temperature Water Immersion**

Contrast temperature water immersion is the immersion of part of the body in water at temperatures of more than 30 °C and less than 15 °C respectively. The alternating hot and cold temperature results in a pumping action that helps recovery by increasing blood flow and assist in the removal of metabolic by-products. There is no research available to support the use of contrast therapy as part of a recovery regime.

### **Passive Recovery or Complete Rest**

Passive recovery or rest is a natural and most common thing for a body to do when tired. During rest the heart rate and metabolism slow down and muscles use less energy.

Unfortunately there is no specific scientific evidence to tell us the most advantageous time and frequency to rest for optimal recovery. Other recovery modalities such as active recovery have been shown during research to be more effective than passive recovery.

### **Active Recovery**

To warm down or recover actively after exercise is a commonly used principle. During active recovery in the upright position more blood is shifted to the legs, causing the muscle in the legs to pump the blood back to

the heart and increase the blood flow. This increase in the blood flow increases the metabolism and helps to restore energy levels and the removal of metabolic by-products. This assist the recovery process and healing of damaged muscles.

Active recovery includes any form of exercise done at a slow heart rate. It is recommended to perform the same type of activity as the activity you wish to recover from, for example running or walking for runners. Unfortunately there is no available literature to specify the most effective timing or duration of active recovery.

### **Stretching**

Stiff and painful muscles are commonly associated with overtraining and exercise. This muscle stiffness can increase immediately after exercise and may last for up to five days. Overtraining causes structural changes to the muscle fibres. Stretching a stiff muscle causes changes in the muscle fibres, possibly leading to faster recovery.

Although there is no conclusive research to support it, stretching prior to activity is commonly used all over the world to prevent injuries. The perceived effect of stretching is to improve flexibility, to relax muscles and to reduce muscle soreness and stiffness. Some research recommends stretching to increase the muscle length, as reduced flexibility is a risk factor for muscle injuries. But lately research is conducted on the ability of the muscle to control lengthening (or eccentric working) during activity. It seems that controlling the movement and length of a muscle may be more important than the flexibility of a muscle to prevent injuries. When a muscle is tired the ability to control the lengthening of a muscle is reduced. A tired muscle therefore has a reduced ability to absorb energy and is at higher risk for injuries. There is some scientific evidence to suggest that pre-exercise stretching must be done carefully to avoid over stretching. Over stretching can lower the pain threshold of a muscle and has been associated with increased muscular fatigue. It is therefore recommended to rather stretch after exercise. Avoid stretching into pain, hold each stretch 20 – 30 seconds and repeat each stretch twice.

### **Massage**

Massage is widely used and can include a variety of different techniques. Massage increases blood circulation as is evident by the redness of the skin during and after a massage. It can decrease the inflammatory response and muscle spasm while resulting in muscle relaxation and improved flexibility and range of motion.

Massage is commonly used before and after exercise and races as a recovery modality. Massage has a psychological effect, lowering stress levels and creating a feeling of well-being that may play a role during recovery, but there is no evidence that massage really has an impact as a recovery modality.

### **Compression Garments**

Compression garments are available in different shapes and sizes, from full body suits to socks covering the lower legs. There is little scientific evidence to prove the effect of compression garments during the recovery process. Compression garments are thought to increase the blood circulation by assisting the muscle pump action mechanism. It improves the removal of metabolites, increases the flow of oxygen to the muscles and reduces swelling. Thus compression garments may reduce muscle pain and fatigue.

Most literature recommends gradual compression garments as it may possibly be effective in assisting the normal venous blood flow from the ankle to the heart without causing a tourniquet effect. Compression garments must to be worn immediately after strenuous or prolonged exercise to improve recovery, but the ideal duration to wear these garments has not yet been established.

## 12 Appendix G: Additional analyses

Table 12-1: The fastest and slowest training pace reported. Data are expressed as numbers (n) and percentages (%) of participants.

Training pace	Slowest training pace			Fastest training pace		
	Female n = 154	Male n = 279	Total n = 433	Female n = 154	Male n = 279	Total n = 433
3:00-3:15 min/km	1 (1%)	0 (0%)	1 (0.02%)	1 (1%)	3 (1%)	4 (1%)
3:16-3:30 min/km	0 (0%)	0 (0%)	0 (0%)	1 (0.6%)	12 (4%)	13 (3%)
3:31 – 3:45min/km	0 (0%)	0 (0%)	0 (0%)	1 (1%)	18 (7%)	19 (4%)
3:46-4:00 min/km	0 (0%)	1 (0.4%)	1 (0.02%)	4 (3%)	25 (9%)	29 (7%)
4:01 – 4:15 min/km	0 (0%)	0 (0%)	0 (0%)	9 (6%)	28 (10%)	37 (9%)
4:16-4:30 min/km	1 (1%)	1 (0.4%)	2 (0.05%)	3 (2%)	34 (12%)	37 (9%)
4:31-4:45 min/km	3 (2%)	1 (0.4%)	4 (1%)	14 (9%)	35 (13%)	49 (12%)
4:46-5:00 min/km	1 (1%)	2 (1%)	3 (1%)	21 (14%)	29 (10%)	50 (12%)
5:01-5:15 min/km	4 (3%)	9 (3%)	13 (3%)	20 (13%)	26 (9%)	46 (11%)
5:16-5:30 min/km	3 (2%)	16 (6%)	19 (4%)	17 (11%)	18 (7%)	35 (8%)
5:31-5:45 min/km	6 (4%)	28 (10%)	34 (8%)	20 (13%)	14 (5%)	34 (8%)
5:46-6:00 min/km	13 (8%)	36 (13%)	49 (11%)	14 (9%)	15 (5%)	29 (7%)
6:01-6:15 min/km	23 (23%)	42 (15%)	65 (15%)	13 (8%)	9 (3%)	22 (5%)
6:16-6:30 min/km	28 (18%)	29 (10%)	67 (16%)	7 (5%)	7 (2%)	14 (3%)
6:31-6:45 min/km	9 (6%)	24 (9%)	33 (8%)	2 (1%)	0 (0%)	2 (1%)
6:46-7:00 min/km	8 (5%)	21 (8%)	29 (7%)	0 (0%)	2 (1%)	2 (1%)
7:01-7:15 min/km	15 (10)	16 (6%)	31 (7%)	0 (0%)	2 (1%)	2 (1%)
7:16-7:30 min/km	15 (10%)	13 (5%)	28 (6%)	0 (0%)	2 (1%)	2 (1%)
7:31-7:45 min/km	6 (4%)	3 (1%)	9 (2.1%)	0 (0%)	0 (0%)	0 (0%)
7:46-8:00 min/km	10 (6%)	8 (3%)	18 (4%)	1 (1%)	0 (0%)	1 (0.4%)
8:01-8:15 min/km	1 (1%)	2 (1%)	3 (0.6%)	0 (0%)	0 (0%)	0 (0%)
8:46-9:00 min/km	5 (3%)	5 (2%)	10 (2%)	1 (1%)	0 (0%)	1 (0.4%)
More than 10 min/km	2 (1%)	5 (2%)	7 (2%)	1 (1%)	0 (0%)	1 (0.2%)

**Table 12-2: Fitness level satisfaction.**

Fitness level satisfaction					
<b>Very satisfied</b>	26 (17%)	68 (24%)	94 (22%)	5.87	0.21
<b>Satisfied</b>	85 (55%)	154 (55%)	239 (55%)		
<b>Neutral</b>	34 (22%)	41 (15%)	75 (17%)		
<b>Dissatisfied</b>	8 (5%)	15 (5%)	23 (5%)		
<b>Very dissatisfied</b>	1 (0.5%)	1 (0.5%)	2 (0.5%)		

**Table 12-3: Other recovery modalities reported.**

Other recovery modalities	Number of participants
<b>Sleep</b>	5
<b>Beer and wine</b>	2
<b>Recoverite-mineral recovery drink</b>	1
<b>Olives or other salty foods</b>	1
<b>Electric Stimulation</b>	1
<b>Acupuncture</b>	1
<b>Taking very short steps when walking.</b>	1
<b>Body Tec</b>	1
<b>X-Spider Tape</b>	1
<b>PRP injection</b>	1
<b>Cortisone injections</b>	1
<b>Warm Epsom salt bath</b>	1

Please note: Sleep has not been included under passive recovery is an avoidance of any exercise.

## 13 Appendix H: Forward stepwise regression analyses

Table 13-1: Regression analyses for passive recovery.

Passive recovery		
Model	Predictor variable	p
Demographic	Gender	0.67
	Age	0.34
	Body mass index (BMI)	0.38
	Highest level of education	0.60
	Monthly income	0.25
Training	Training distance	0.16
	Running experience	0.68
	Running preference	0.66
	Marathon frequency	0.64
	Current injuries	0.54

Table 13-2: Regression analyses for active recovery.

Active recovery		
Model	Predictor variable	p
Demographic	Gender	0.49
	Age	0.009**
	Body mass index (BMI)	0.14
	Highest level of education	0.25
	Monthly income	0.32
Training	Training distance	0.009**
	Running experience	0.11
	Running preference	0.61
	Marathon frequency	0.98
	Current injuries	0.09

\*\* p < 0.01; \* p < 0.05

**Table 13-3: Regression analyses for stretching.**

<b>Stretching</b>		
<b>Model</b>	<b>Predictor variable</b>	<b>p</b>
<b>Demographic</b>	Gender	0.29
	Age	0.86
	Body mass index (BMI)	0.82
	Highest level of education	0.19
	Monthly income	0.69
<b>Training</b>	Training distance	0.40
	Running experience	0.90
	Running preference	0.45
	Marathon frequency	0.12
	Current injuries	0.22

**Table 13-4: Regression analyses for protein.**

<b>Protein</b>		
<b>Model</b>	<b>Predictor variable</b>	<b>p</b>
<b>Demographic</b>	Gender	0.59
	Age	0.48
	Body mass index (BMI)	0.49
	Highest level of education	0.74
	Monthly income	0.049*
<b>Training</b>	Training distance	0.18
	Running experience	0.74
	Running preference	0.65
	Marathon frequency	0.18
	Current injuries	0.73

\*\* p < 0.01; \* p < 0.05



**Table 13-5: Regression analyses for cryotherapy.**

<b>Cryotherapy</b>		
<b>Model</b>	<b>Predictor variable</b>	<b>p</b>
<b>Demographic</b>	Gender	0.08
	Age	0.32
	Body mass index (BMI)	0.57
	Highest level of education	0.95
	Monthly income	0.14
<b>Training</b>	Training distance	0.15
	Running experience	0.24
	Running preference	0.90
	Marathon frequency	0.63
	Current injuries	0.001**

\*\* p < 0.01; \* p < 0.05

**Table 13-6: Regression analyses for anti-inflammatory medication.**

<b>Anti-inflammatory medication</b>		
<b>Model</b>	<b>Predictor variable</b>	<b>p</b>
<b>Demographic</b>	Gender	0.94
	Age	0.004**
	Body mass index (BMI)	0.55
	Highest level of education	0.69
	Monthly income	0.24
<b>Training</b>	Training distance	0.14
	Running experience	0.89
	Running preference	0.24
	Marathon frequency	0.02*
	Current injuries	0.12

\*\* p < 0.01; \* p < 0.05

**Table 13-7: Regression analyses for massage.**

<b>Massage</b>		
<b>Model</b>	<b>Predictor variable</b>	<b>p</b>
<b>Demographic</b>	Gender	0.13
	Age	0.23
	Body mass index (BMI)	0.33
	Highest level of education	0.26
	Monthly income	0.002**
<b>Training</b>	Training distance	0.80
	Running experience	0.54
	Running preference	0.18
	Marathon frequency	0.18
	Current injuries	0.42

\*\* p < 0.01; \* p < 0.05

**Table 13-8: Regression analyses for vitamins and minerals.**

<b>Vitamins and minerals</b>		
<b>Model</b>	<b>Predictor variable</b>	<b>p</b>
<b>Demographic</b>	Gender	0.36
	Age	0.13
	Body mass index (BMI)	0.61
	Highest level of education	0.79
	Monthly income	0.85
<b>Training</b>	Training distance	0.19
	Running experience	0.93
	Running preference	0.04*
	Marathon frequency	0.005**
	Current injuries	0.22

\*\* p < 0.01; \* p < 0.05

**Table 13-9: Regression analyses for compression.**

<b>Compression</b>		
<b>Model</b>	<b>Predictor variable</b>	<b>p</b>
<b>Demographic</b>	Gender	0.53
	Age	0.03*
	Body mass index (BMI)	0.80
	Highest level of education	0.64
	Monthly income	0.99
<b>Training</b>	Training distance	0.04*
	Running experience	0.76
	Running preference	0.01*
	Marathon frequency	0.32
	Current injuries	0.42*

\*\* p < 0.01; \* p < 0.05

**Table 13-10: Regression analyses for carbohydrates.**

<b>Carbohydrates</b>		
<b>Model</b>	<b>Predictor variable</b>	<b>p</b>
<b>Demographic</b>	Gender	0.04*
	Age	0.132
	Body mass index (BMI)	0.61
	Highest level of education	0.79
	Monthly income	0.85
<b>Training</b>	Training distance	0.44
	Running experience	0.27
	Running preference	0.99
	Marathon frequency	0.43
	Current injuries	0.24

\*\* p < 0.01; \* p < 0.05

**Table 13-11: Regression analyses for heat.**

Heat		
Model	Predictor variable	p
Demographic	Gender	0.90
	Age	0.97
	Body mass index (BMI)	0.92
	Highest level of education	0.11
	Monthly income	0.21
Training	Training distance	0.26
	Running experience	0.93
	Running preference	0.63
	Marathon frequency	0.14
	Current injuries	0.04*

\*\* p < 0.01; \* p < 0.05

**Table 13-12: Regression analyses for contrast therapy.**

Contrast therapy		
Model	Predictor variable	p
Demographic	Gender	0.80
	Age	0.33
	Body mass index (BMI)	0.46
	Highest level of education	0.62
	Monthly income	0.76
Training	Training distance	0.42
	Running experience	0.82
	Running preference	0.52
	Marathon frequency	0.03*
	Current injuries	0.001**

\*\* p < 0.01; \* p < 0.05

**Table 13-13: Regression analyses for perceived effectiveness of recovery modalities.**

<b>Predictor variable</b>	<b>p</b>
Number of recovery modalities used	0.48

## 14 Appendix I: Ethics approval letter



**UNIVERSITY OF CAPE TOWN**  
**Faculty of Health Sciences**  
**Human Research Ethics Committee**



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Website: [www.health.uct.ac.za/research/humanethics/forms](http://www.health.uct.ac.za/research/humanethics/forms)

21 January 2014

**HREC REF: 379/2013**

**Dr T Burgess**  
Physiotherapy  
Health & Rehab  
F45, OMB

Dear Dr Burgess

**PROJECT TITLE: THE USE OF RECOVERY MODALITIES IN ENDURANCE RUNNERS**

Thank you for your letter to the Faculty of Health Sciences Human Research Ethics Committee dated 21<sup>st</sup> January 2014.

It is a pleasure to inform you that the HREC has **formally approved** the above-mentioned study.

**Approval is granted for one year until the 30<sup>th</sup> January 2015**

Please submit a progress form, using the standardised Annual Report Form if the study continues beyond the approval period. Please submit a Standard Closure form if the study is completed within the approval period.

(Forms can be found on our website: [www.health.uct.ac.za/research/humanethics/forms](http://www.health.uct.ac.za/research/humanethics/forms))

***We acknowledge that the student Hanette Lemke is also involved in this study.***

Please note that the ongoing ethical conduct of the study remains the responsibility of the principal investigator.

Please quote the HREC reference no in all your correspondence.

Yours sincerely

**PROFESSOR M. BLOCKMAN**  
**CHAIRPERSON, FHS HUMAN ETHICS**

Federal Wide Assurance Number: FWA00001637.

Institutional Review Board (IRB) number: IRB00001938

This serves to confirm that the University of Cape Town Human Research Ethics Committee complies to the Ethics Standards for Clinical Research with a new drug in patients, based on the Medical Research Council (MRC-SA), Food and Drug Administration (FDA-USA), International Convention on Harmonisation Good Clinical Practice (ICH GCP) and Declaration of Helsinki guidelines.

HREC Ref 379/2013